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No. 32

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## ERGONOMICS

### APPLICATION OF ERGONOMICS TO AVIATION

Moscow VOZDUZHNYI TRANSPORT 18 April 1978 p 3

[Article by V. Denisov, prorector of the institute, doctor of technical sciences, professor: "How to Draw an Ergonomic Portrait of an Airplane"]

[Text] Until recently the relatively new word "ergonomics" was understood only by a narrow circle of specialists. However, today workers at Aeroflot are required to study this science, which has been introduced broadly in practice.

Ergonomics is an outgrowth of the current stage of the scientific-technical revolution. Its name is a combination of two Greek words: ergon--work, performance, and nomik--law.

Previously, when machines and mechanisms were relatively simple, man was successful in creating, operating and maintaining them, utilizing only his own intuition and experience. But technology is improving constantly, and all the tasks which are performed with this technology are more complicated. Presently, the interactions of man and machine in this process have blended together as if into a single unit. The role of the operator in this system has increased significantly. The task of ergonomics is to guarantee the best working conditions for the operator and to prevent him from making mistakes.

Take for example, the work of a pilot. During the past 30 years, the number of control and navigation instruments in the cabin of an airplane has been increased tenfold--in the modern airliner, there are more than 600 "contact points" for the pilot with technology! But the psychophysiological resources of the man who is piloting the machine has been altered barely during this time. Moreover, with the increase in speed capacity, the time which the pilot has to make the appropriate adjustment in a critical situation has been reduced sharply. The same is true for the work of the control tower which, in complicated conditions, directs the landing of airplanes by instruments.

And how the work of the engineering staff has become more complicated! In a relatively short time specialists must detect an incipient malfunction in the complex systems of the airliner, repair the assembly, or replace one or another malfunctioning parts.

One of the problems on which specialists in aviation ergonomics are working is power compatibility. During the operation of machines situations can arise in which either a very large or very small force is required to change the control levers. It has been found that both levels of force are inconvenient for the operator. It is necessary to construct control instruments and to select a specific kind of operator so that both machine and operator are suited precisely to each other in relation to the control force required.

Biotechnical compatibility is of no lesser importance in the modern relationship of "man and machine." For an operator to be able to work successfully, a very specific work environment with proper external conditions is necessary. We attach great significance to spatial-anthropometric compatibility. Each man has a certain height, arm and leg length. Some postures while working with a machine are comfortable for him and others are not very comfortable. Spatial-anthropometric compatibility of operator and machine involves creating the most comfortable working place--comfortable seats, correctly arranged control panels and the like.

The aesthetic satisfaction engendered by work has a particular nature--enjoyment of the beauty of the very process of labor. A beautiful machine or product creates a sensation of joy. The external appearance of a machine, its shape, its entire performance must be coordinated with its functional purpose and be technically and economically sound.

Ergonomic planning for one of the new airplanes based on the general plan of designer O. K. Antonov yielded very high results: in comparison to earlier airplanes developed for an analogous assignment the amount of work for the crew was reduced by 20-40 percent because equipment and distribution of work among members of the crew was improved. The cabin produced for the testing of the An-72 airplane differs radically from the cabin in former airplanes--it is more spacious, more aesthetic and the number of instruments in it is reduced almost by one-half.

In the process of aircraft instruction for the crew, a large role has been assigned to the training model. In recent years, and more so now, the basic attention of researchers, designers, and skilled workers has been focused on the statistical, dynamic, and informational characteristics of the training model in order to simulate the actual characteristics of an aircraft during a real flight. This task includes equipping the trainers with a special apparatus which an instructor-pilot can convert into an active operator.

Presently, in socialist-economic systems a large "role" has been found for ergonomics. Here, we approach a problem that necessitates an indepth

study--the so-called "ergonomic portrait" of a project--and develop recommendations for its improvement. This approach has enabled a significant increase in the effectiveness and safety of flights as well as an improvement in the working conditions for aviators.

It is necessary to study all these questions of labor protection, active longevity of operators and work-related diseases by applying the methods of aviation ergonomics. In conjunction with medicine aviation ergonomics must solve the problems of rational organization of work and rest for operators as well as the problems of fighting exhaustion. Presently, scientists at KIIGA [Kiev Industrial Institute for Civil Aviation] and skilled worker-specialists from the Mineralvodskiy Aviation Enterprise are engaged in work to construct, by means of technical aesthetics and ergonomic apparatus, an ergonomic room in which, owing to a planned microclimate, it will be possible to a) "lower" the fatigue and strain of crew members before and after flight, and b) "lower" the fatigue of air-traffic controllers who will be able to spend their temporary rest periods during work in such a room.

The many specialists of Aeroflot must be armed with knowledge of ergonomics. In this regard it is advisable to hasten resolution of the question about introducing a course in "aviation ergonomics" at the training schools in our field.

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CSO: 1870

## ERGONOMICS

### NEW MONOGRAPH ANALYZES DIGITAL AVIATION MONITORING AND CONTROL SYSTEMS

Moscow TEKHNIЧЕСКАЯ ЭСТЕТИКА in Russian No 3, 1978 p 19

[Review by Cand Psych Sci N. G. Alekseyev, USSR Academy of Psychological Sciences Corresponding Member, Dr Psych Sci V. P. Zinchenko, and Cand Psych Sci V. M. Munipov of the book "Aviatsionnyye i tsifrovyye sistemy kontrolya i upravleniya" (Aviation and Digital Monitoring and Control Systems) edited by V. A. Myasnikov and V. P. Petrov, Leningrad, Izdatel'stvo Mashinostroyeniye, 1976]

[Text] The annotation of this work states: "The goal of the book offered to the reader is to present the principles of optimum planning of aviation monitoring and control systems solving navigational and special problems." In six sections the monograph discusses various aspects of creating onboard electronic complexes--from writing the algorithms of an onboard digital computer to planning electronic complexes on the basis of the criteria of electromagnetic compatibility, and analysis of the effectiveness of new monitoring and control systems. Part 5 of the book, "Consideration of the Factors of Engineering Psychology in Electronic Complex Planning," which takes up about a third of the book, is devoted to ergonomic problems and was written by a collective of authors (M. I. Gal'perin, G. M. Zarakovskiy, M. V. Kuznetsova, A. I. Naftul'yev, V. P. Petrov, V. V. Rassvetayev, Yu. M. Smirnov, and A. A. Frumkin).

Systematizing the experience of ergonomic analysis within an individual sector of engineering planning would in fact be equivalent to establishing the ergonomic principles of the particular sector. We believe that this is where the main significance of this book lies. An important transition is made from an ergonomics handbook intended basically for all users to a specialized monograph addressed to engineers and planners of a distinctly outlined profile. This fact reflects differentiation of ergonomic knowledge, proceeding in connection with general development of ergonomics, with its spread into more and more new areas of research and planning, and it reflects arisal of specialized sector ergonomics in addition to general ergonomics; in specialized ergonomics, the premises of general ergonomics are developed and made specific in application to the unique features of the concrete type of activity being studied and planned.

The teaching function is basic to sector ergonomics; its goal is to arm specialists with concrete knowledge necessary for solution of a limited though perhaps very broad range of special problems. This also requires special organization of the material presented. From this standpoint it would be interesting to look at the structure and form of presentation of the material in the book's section on ergonomics.

We believe that the most effective general principles for presenting the procedures was employed. The pattern is as follows. First a general impression is given of the possible directions of ergonomic work in the planning of electronic complexes, and then the basic ergonomic problems that have to be solved are described in detail; in this case the description is concrete. The section ends with an elaborate description of two methods for studying the activity of a pilot (electronic complex operator) having general significance. Let us look at these components in greater detail.

After isolating the general goal of ergonomic work--analysis of the laws governing pilot activity, the authors classify the possible particular goals (isolating 19 types) and, correspondingly, the directions of ergonomic research in this sector. These goals (directions) are grouped into major units of greater generality, to which certain research and planning procedures correspond. The "fruits" of ergonomic work are defined as well: The system of indices for assessing effectiveness, intensity, satisfaction of ergonomic principles, and so on is given (and explained). In addition to providing a general impression of ergonomic work in aviation as a whole, what the book in fact does is demonstrate the place of any concrete study performed within this area--its dependence on and relationship to other directions.

This general impression is supplemented by a discussion of the stages of ergonomic analysis corresponding to the basic stages of electronic complex planning: The technical assignment, the technical proposal, the sketches, the technical plan, and the working documents. Demonstration of the unique features of ergonomic work in these different planning stages produces a more-complete and deeper picture.

As was noted above, a significant amount of room is devoted to analysis of the most typical ergonomic problems solved during the planning and operation of electronic complexes. Among them we can include traditional problems such as optimization of control consoles, the specific features of selecting keyboard devices, mathematical modeling of work modes, and self-monitoring of psychophysiological state. Specific problems include use of the vibrotactile analyzers as a supplementary communication channel, and analysis of pilot activity in low-altitude flight. A system of examples to be used in subsequent concrete ergonomic work is developed through analysis of the resources and procedures for solving these problems.

The monograph examines two general methods for studying the activity of a human operator: A computation method--operational-psychophysiological, and an experimental method--cyclographic. The first method is based on isolating

and classifying the typical actions of an operator; these actions are assessed in relation to reliability (which is interpreted as a function of error-free work) and in relation to the time of these actions; the intensity of the actions is also accounted for in points. Next in accordance with the algorithm of activity, the obtained numerical values for the individual actions are added together (synthesized) with the goal of characterizing the load upon the operator (pilot) during performance of some particular block of independent actions. In this case we make use of coefficients, acquired by generalizing the experimental data, accounting for the mutual influence of the actions and their dependence upon work pace and other intensity factors. An example is given of a concrete assessment of operator mode using this method. A unique feature of the cyclographic method is performance of an experiment in which a number of quantitative indices are automatically recorded. Specialists in ergonomics working in aviation are thus given general methods for analyzing, assessing, and computing the activity of an operator in a system.

Being one of the first attempts at presenting ergonomics in relation to a particular sector, the monograph does have a number of shortcomings. Here are a few of them. Definition of ergonomics as a complex of sciences on labor activity was unfortunate (p 383); the specific features of this discipline are lost in such a definition. The authors make broad use of, and even employ in a title, the term "engineering-psychological factor" in reference to description of operator activity. It should be noted that the following distinction has already been made in psychology: Psychological resources, methods, and approaches, and mental laws, features, and so on. From this point of view it would probably have been more acceptable to use the term "human factor" or, in an expanded version, "the human factor in technology."

Methods for studying operator activity in which the formation itself of the developing action and its individual components is taken into account were not discussed in the monograph. In our opinion they could have afforded a possibility for, in particular, correcting the numerical values of the load of a human operator obtained by the operational-psychophysiological method. Although the bionic method for assessing the state of a pilot in flight (use of an index such as electric activity of specific points employed in ancient Chinese practical medicine) was mentioned, it was not described fully in the monograph, and its scientific grounds were not stated. The excessive optimism concerning the promise of this new method and the possibility that it might replace other resources for monitoring pilot state are at least doubtful today.

These shortcomings do not diminish the generally favorable impression given by this work, written at a high professional level and in organic association with technical engineering problems of the planning of aviation monitoring and control systems. Without a doubt it will be useful to specialists in ergonomics working in aviation. Ergonomic specialists in other spheres of production will also read it with interest.

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NEW METHODS OF ISOLATING EUKARYOTE GENES

Moscow PRIRODA in Russian No 6, 1977 pp 85-91

[Article by A. P. Ryskov]

[Text] Aleksey Petrovich Ryskov, candidate of biological sciences, is a senior scientific worker in the laboratory of biosynthesis of nucleic acids, Institute of Molecular Biology, USSR Academy of Sciences. He studied under G. P. Georgiyev. He is concerned with problems of structural organization and function of animal genes. At the present time, he is also working in the field of gene engineering.

A new direction in modern biology, gene engineering, emerged as a result of significant progress in the field of molecular biology and molecular genetics. Already the first results of gene engineering are indicative of the prospects of new methods involving the use of hybrid molecules. Future development of this field will make it possible to produce some substances that are rather scarce in quantities needed for experimental purposes. Particular expectations are held for industrial production of a number of biologically active proteins and hormones of human origin (for example, immunoglobulins, growth hormones, human insulin). All this is causing rapid dissemination of methods of gene engineering in scientific research, as well as interest of the broad community.

Our article deals with one of the focal and still little-developed methodological problem, that of obtaining eukaryote genes for hybrid or, so-called recombinant, molecules.

At the present time, the problem of artificial synthesis of genetic structures, recombinant molecules consisting of fragments of DNA of diverse origin, can be considered essentially solved. However, our capabilities are presently limited because of some technical difficulties, related to the complex structure of the genetic system, particularly in the case of higher organisms. The recombinant molecule consists of DNA of bacterial or viral origin, so-called vector, which enables the entire molecule to survive and multiply for a rather long time in a suitable medium,<sup>1</sup> and a gene or segment of DNA of another organism which is to be reproduced.

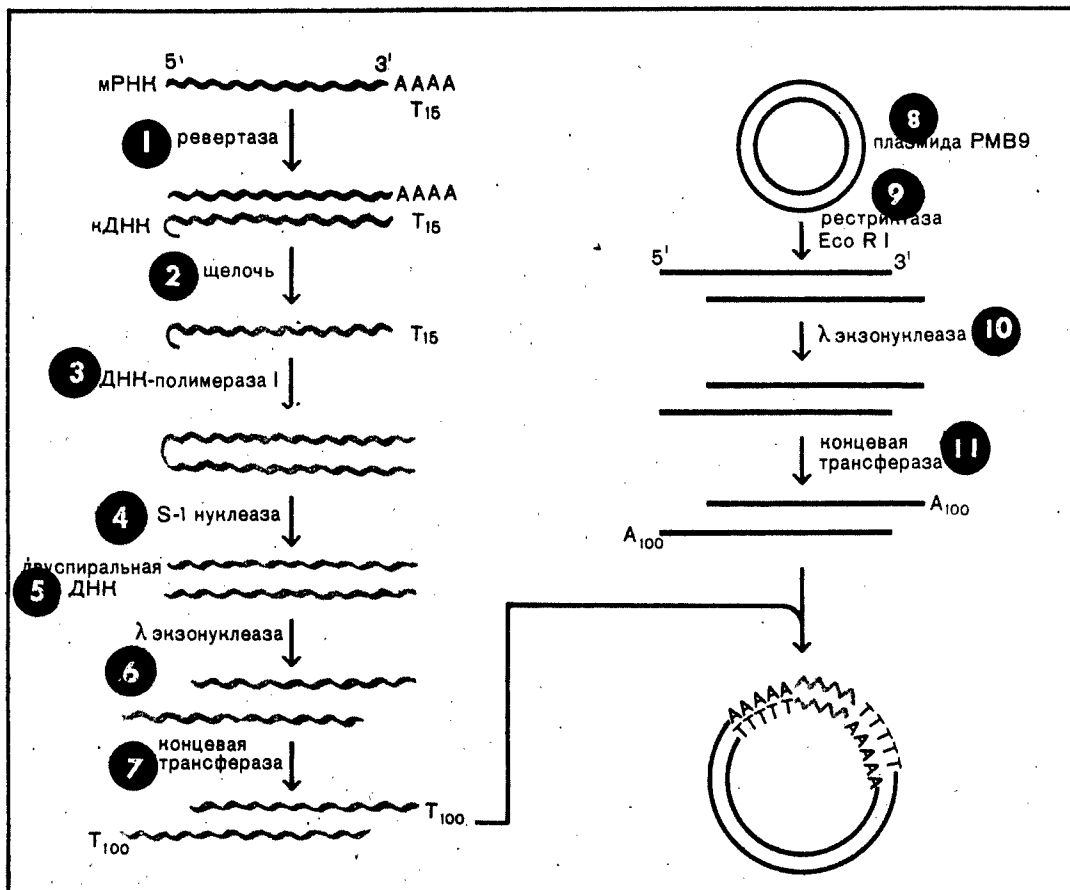


Diagram of globin gene synthesis and insertion in plasmid DNA (according to T. Maniatis et al., 1976).

Left: single-stranded complementary DNA (кДНН) with terminal spindle synthesized on a template of globin mRNA (мРНК) using the enzyme, revertase. Then the mRNA is removed with alkali, while complementary DNA is built up to a double helical globin DNA in the presence of the enzyme, DNA polymerase I. Using the enzyme, terminal transferase, fragments are obtained of globin DNA with thymidine nucleotides on the ends. The globin gene thus isolated is hybridized with the DNA of plasmid RMB9, pretreated in an analogous manner (on the right), and the hybrid molecule is obtained. A<sub>100</sub>, T<sub>15</sub> and T<sub>100</sub> refer to the number of adenine and thymidine nucleotides.

Key:

- |                     |                          |
|---------------------|--------------------------|
| 1) revertase        | 7) terminal transferase  |
| 2) alkali           | 8) plasmid PMB9          |
| 3) DNA polymerase   | 9) Eco RI restrictase    |
| 4) S-1 nuclease     | 10) λ exonuclease        |
| 5) double-helix DNA | 11) terminal transferase |
| 6) λ exonuclease    |                          |

One generally uses one of two methods, which have already become classical, to obtain a recombinant molecule, i.e., for covalent union of vector DNA and DNA-gene. Both are based on producing so-called sticky ends in these DNA. This refers to single-chain sites on the ends of the DNA molecules that interact with one another by the complementarity principle, linking molecules with hydrogen bonds. The first method, which is more universal but technically rather complex, involves synthetic addition of sticky ends. The second method is based on the use of certain specific restrictive endonucleases, restrictases. It is known that restrictases dissociate double-stranded DNA in strictly specific nucleotide sequences. It was found that sticky ends are formed in DNA under the influence of some of them. When vector DNA and DNA-gene are jointly treated with such restrictase, a mixture of fragments with sticky ends is formed. These fragments react with one another and could then be covalently united by the enzyme, polynucleotide ligase. This method has gained more popularity for obtaining recombinant molecules, although it cannot be used in all instances.

The proceedings of a conference on recombinant molecules, which convened in Miami (United States) in January 1977, revealed that the greatest progress has now been achieved in the area of obtaining new vector molecules, as well as methods of linking the vector DNA with DNA-genes. Most works deal with these matters, and some important results have been obtained. It should be borne in mind that various problems are solved by obtaining new vectors. The new vectors should be more suitable (as compared to already existing ones) for solving a given problem. Moreover, vectors are being developed that meet certain safety levels. At the present time, vectors and specific *E. coli* strains have already been obtained that meet the requirements of utmost safety. Many (probably dozens) of various vectors are used in practical laboratory work, and development of new vectors has already moved to the area of purely technical problems.

There has been substantial expansion in recent times of the arsenal of methods for linking the vector DNA and DNA-gene. Thus, it was found that, under specific conditions, polynucleotide ligase can connect DNA fragments without sticky ends (blunt end ligation). Increasing use is being made of so-called adaptors, i.e., fragments of DNA of natural or synthetic origin containing a nucleotide sequence that is specific to a given restrictase. These adaptors are united with other DNA fragments, forming sticky ends of the required specificity. Obviously, the use of classical and new methods together alleviates significantly the task of obtaining recombinant molecules.

Further operations with recombinant molecules consist of inserting them in a bacterial or animal cell, reproduction and selection of the needed ones, which contain the required molecular genes. Obtaining such genes in sufficient quantity for experimentation is one of the researcher's primary objectives. Unfortunately, there is a rather limited choice of DNA-genes used to obtain recombinant molecules. This is related to the difficulties involved in obtaining them from natural sources. There has been a description of isolation from total DNA of some frequently repeated genes with a specific nucleotide composition (coding ribosomal, transport and histone RNA) with the

standard biochemical methods.<sup>2</sup> However, these methods are far from universal. We shall discuss the basically new approaches, which have emerged along with development of gene engineering, as well as those that are being developed in recent times, both in our country and abroad.

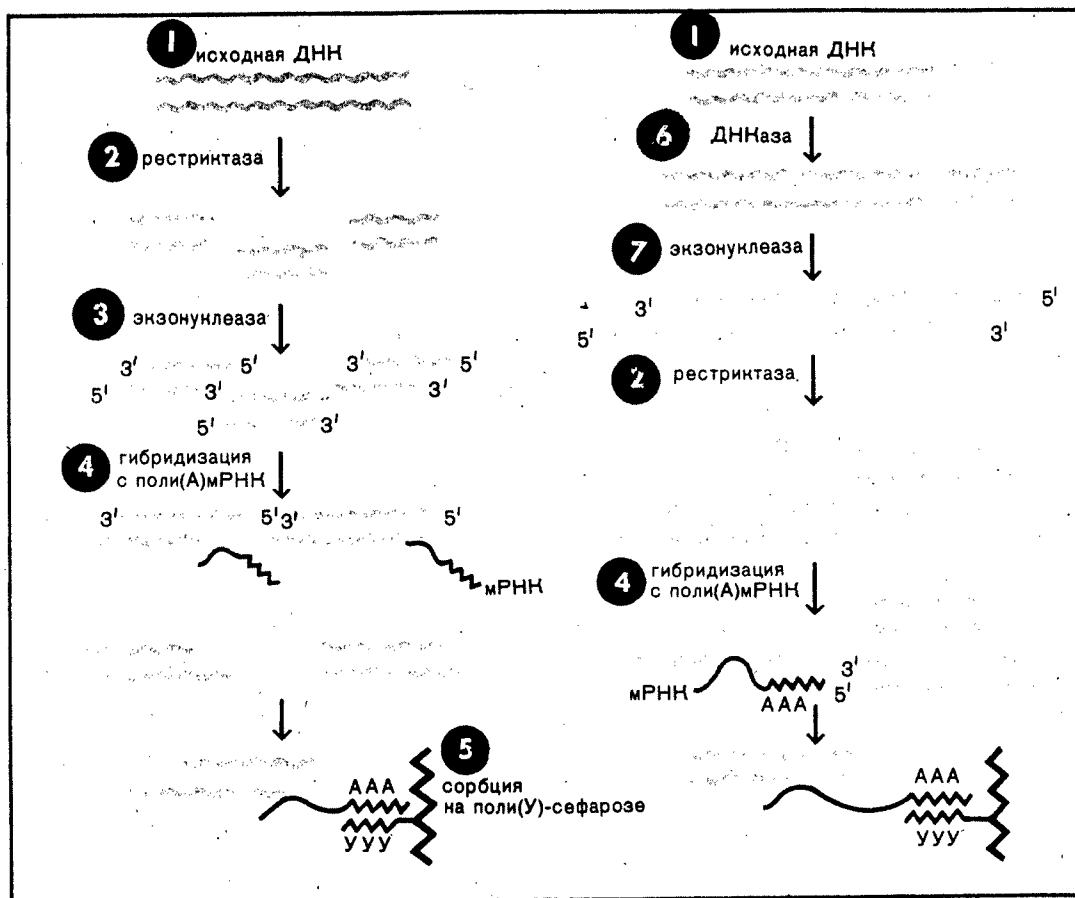


Diagram of isolation of native DNA fragments containing structural genes.

Left: structural genes at the end of the fragment. The original DNA is separated by means of restrictase. Exonuclease treatment permits obtaining fragments with single-chain ends. Under specific conditions, some of these fragments are linked with poly(A)mRNA. Then, hybrid molecules are isolated on a column filled with the adsorbent, poly(U)sepharose. Right: there is some change in treatment procedure to obtain single-chain segments in the middle of the DNA molecule. Before the stage of separation of the DNA molecule with restrictase, there is pretreatment with DNAase and exonuclease. In this manner fragments are obtained with structural genes in the middle of the molecule, which are then isolated analogously.

Key:

- |                 |                  |                  |                |
|-----------------|------------------|------------------|----------------|
| 1) original DNA | 4) hybridization | 5) sorption on   | 6) DNAase      |
| 2) restrictase  | with poly(A)mRNA | poly(U)sepharose | 7) exonuclease |
| 3) exonuclease  |                  |                  |                |

## The "Shotgun" Method

Since researchers have a limited number of DNA-genes, they began to use primarily total DNA, separated or, figuratively speaking, cut up by restrictases as the gene source to obtain recombinant molecules. This technique was named the shotgun method. As a result of exposing it to restrictase, DNA breaks down into numerous fragments, some of which contain genes. The population of such molecules is reproduced in a bacterial system, followed by testing and selection of the required genes. Usually, radioactive messenger RNA (mRNA), corresponding to a given gene, is used as the test sample. In principle, the method permits isolation of both recurring and unique genes. It should be noted that most genes are referable to unique fractions (i.e., they are present in DNA in one or several copies). The difficulty of collecting unique genes is related expressly to their low concentration in total DNA. For example, in restrictase fragments of total DNA, there is one fragment of unique gene per million other fragments. For this reason, it is expedient to use in experiments DNA that is pre-enriched with the required genes.

Structural genes have already been obtained from total, unseparated DNA of a number of objects. For example, S. Cohen et al. and D. Hogness et al. isolated clones, from the DNA of the sea urchin and drosophila, which contain histone and ribosomal genes. This method was used at the Institute of Molecular Biology, USSR Academy of Sciences, in the laboratory of G. P. Georgiyev, in collaboration with the Institute of Atomic Energy imeni I. V. Kurchatov (V. A. Gvozdev et al.), to obtain several structural genes from drosophila DNA. Since this object has been well studied genetically, it is interesting to make a direct determination of localization and possible function in the chromosome of the isolated structural genes. However, first of all, there were the prospects of determining the general patterns of structure of obtained genes and characteristics of adjacent segments. At the present time, Yu. V. Il'in, N. A. Churikov and G. P. Georgiyev have shown that the DNA of several obtained clones contains both the sequence of the structural gene and recurring genome sites.<sup>3</sup> On the whole, it can be considered that this method is suitable for isolating any required gene, if it is possible to test it and if the experiment is conducted in accordance with the safety rules for working with recombinant molecules.<sup>4</sup>

## In Vitro Gene Synthesis

In 1970, D. Baltimore and H. Temin discovered a new enzyme, which synthesizes DNA molecules on an RNA template, which was named RNA-controlled DNA polymerase, as well as reverse transcriptase, or revertase, in the viruses of Rous sarcoma and Rauscher's leukemia of mice. In 1972, DNA was synthesized with this enzyme on templates of mRNA (template, or mRNA) coding globin proteins of rabbit and man, concurrently in the laboratories of D. Baltimore, S. Spiegelman and P. Leder. Thus, copies of structural genes of eukaryotes were obtained in the test tube for the first time. This work originated extensive research in many laboratories of the world,

including the USSR, on synthesis of DNA complementary with various mRNA. New opportunities emerged for solving many problems of molecular biology and molecular genetics, for example, analysis of structure of eukaryote genomes, investigation of molecular bases of ontogenesis, determination of the nature of hereditary diseases, etc. The possibility of obtaining genetic material with a certain specificity logically led to formulation of the problem of synthesizing double-helix genes for gene engineering purposes. The great advantage of this method is accessibility and purity of mRNA.

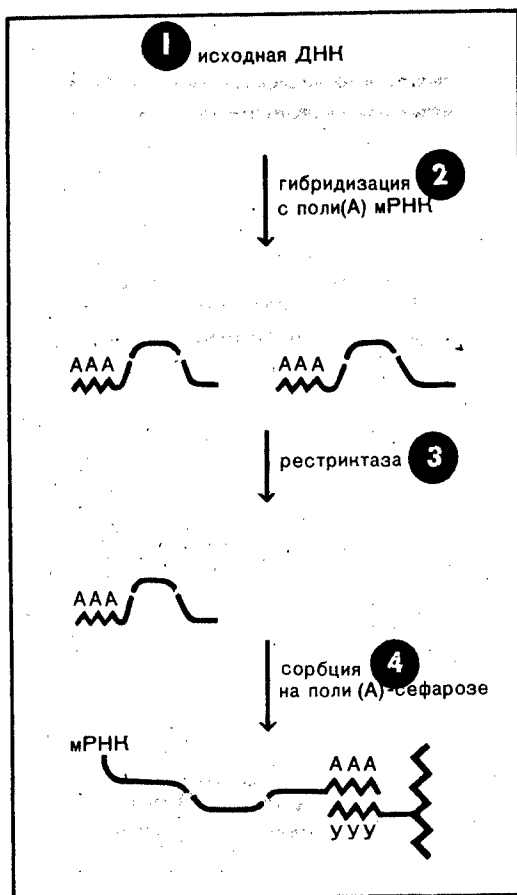


Diagram of isolation of DNA fragments containing structures of the P-loop type. The original native DNA molecule is hybridized with poly(A)mRNA. In specific sites of the molecule, mRNA interacts with DNA, forming structures of the P-loop type. After restrictase treatment, hybrid segments are isolated by the chromatographic method.

Key:

- 1) original DNA
  - 2) hybridization with poly(A)mRNA
  - 3) restrictase
  - 4) sorption on poly(A)sepharose
- mRNA

As was to be expected, rabbit globin gene was synthesized and reproduced in several laboratories simultaneously (V. Makh et al.; T. Maniatis et al.; W. Salser et al.; T. Rebits and K. Wood, G. Dee).<sup>5</sup> This is attributable to the fact that the appropriate mRNA can be isolated in large quantities and in a very pure state. In the experiments of Maniatis, complementary DNA (cDNA) was obtained on a template of globin mRNA using the enzyme, reverse transcriptase (revertase); in turn, this cDNA served as the template for synthesis of the second chain of DNA using another enzyme, DNA polymerase. In the

authors' opinion, the most important link in this chain is synthesis, using revertase, of cDNA with a spindle on the end, which serves as primer for production of the second DNA chain. The synthesized double-helical DNA is closed at the 5' end (with reference to mRNA). At this site, a specific enzyme (DNAase S 1) dissociated the polynucleotide chain and a complete globin gene was obtained. This gene was then inserted in plasmid DNA and submitted to amplification.

T. Rebits developed an original method for inserting the gene in plasmid DNA. The cDNA was synthesized on mRNA prelinked with plasmid DNA via nucleotide sequences. The template RNA was removed with RNAase, and the recombinant molecule containing single-chain globin cDNA was reproduced in bacterial cells. A double-helix globin gene was obtained as a result of the in vivo action of enzyme-repairing bacteria.

Wood and Lee used heteroduplex mRNA-cDNA, obtained in vitro, for insertion in plasmid DNA. When such recombinant molecules were reproduced in *E. coli*, clones with globin genes were also obtained.

By now, genes that code alpha- and beta-globin proteins of the rabbit have been synthesized and reproduced. J. Morrow and A. Yefstratiadis synthesized an incomplete double-helix fibroin gene, while F. Kafatos obtained complete genes coding chorionic mRNA (A and B classes).

A complete double-helix rabbit globin gene was synthesized at the Institute of Molecular Biology, USSR Academy of Sciences, under the supervision of V. A. Engel'gardt, within the framework of the international "Revertase" project, by L. L. Kiselev, L. Yu. Frolova et al., in collaboration with Ch. Kutel et al. (Institute of Molecular Biology, GDR Academy of Sciences), and in collaboration with S. A. Limborskaya et al. (Institute of Medical Genetics, USSR Academy of Medical Sciences) a complete single-chain human globin gene was synthesized.

Intensive research is in progress in several laboratories on synthesis of immunoglobulins (V. Makh et al., T. Rebits) and a few other genes.

#### Isolation of Single-Chain DNA Fragments Enriched With Structural Gene Sequences

DNA synthesis using revertase yields only genes, the size of which does not exceed that of the corresponding template RNA. However, it is also interesting to isolate DNA fragments containing both the structural part of the gene and adjacent sites which, perhaps, have regulatory functions. The overall scheme for solving this problem, using mRNA or cDNA, appeared rather evident, but the first experimental data were obtained only recently. K. Gazaryan et al.<sup>6</sup> and B. O'Malley et al.<sup>7</sup> hybridized mRNA (globin RNA of the pigeon and ovalbumin RNA of the chicken, respectively), using denatured and markedly fragmented DNA, and they separated the formed hybrids by special chromatographic methods. The DNA was enriched with sequences of corresponding

genes. For example, after the first, second and third refinement cycles, the concentration of ovalbumin genes increased by 300, 5200 and 9600 times, respectively. J. Anderson and R. Schimke<sup>8</sup> found another way to isolate ovalbumin sequences from total DNA. They used a column with cellulose containing covalently bound ovalbumin cDNA. After fragmentation to a specific size and denaturation, the total DNA was passed through this column in a circulating system under conditions where there was interaction of complementary chains. The DNA adsorbed on the column was enriched with ovalbumin sequences after one purification cycle by 300 times and by 2300 times after the second cycle. In these experiments, 700 nucleotide long DNA fragments were used, which is 3 times shorter than ovalbumin mRNA and corresponding structural gene. When working with DNA fragments the length of 10,000 nucleotides, there was 10 times poorer purification. This may be attributable to various causes, including increased nonspecific adsorption on the column and aggregation of DNA chains due to reassociation of recurrent segments. The latter cause, if present, restricts appreciably the use of this method, since it does not permit working with long fragments of denatured DNA. It should also be noted that, with all variants of the method, denatured DNA is obtained, which cannot be directly used for gene engineering. Obviously, new approaches must be developed to solve the problem formulated at the beginning of this section.

#### Isolation of Native DNA Fragments Containing Single-Chain Structural Gene Sequences

In 1975, G. P. Georgiyev proposed a new approach for isolating, from total DNA, native double-helical fragments of any desired size, containing structural genes at the ends or in the middle. The method consists of several stages: separation of native DNA to a specific size; dissociation of small segments from the fragments at the ends of one of the chains or within a fragment using specific enzymes; hybridization of mRNA with single-chain segments of fragments; separation of hybrids by special chromatographic methods.

The advantages of this approach are obvious, and they consist of the fact that DNA fragments are in a native state, and they can be used directly to obtain recombinant molecules. It is also important that, when hybridizing native fragments (their single-chain segments are relatively small), the recurrent sequences cannot interact with one another, and as a result there will be greater purification of fragments. At the present time, the different stages of this technique have been refined in our laboratory. Using total preparations of mouse DNA and mRNA, we obtain DNA specimens enriched with an overall population of structural genes.<sup>9</sup> The purity of the isolated fragments depends largely on the chromatographic methods used on the hybrids. In the course of refinement, the hybrid complexes are adsorbed on columns with sepharose containing poly(U) sequences by means of complementary interaction with segments of poly(A) in mRNA. The second cycle of purification can be conducted on another type of column, with cellulose (or sepharose) containing SH groups. In this case, ions of mercury are first applied to mRNA, and this RNA is used for hybridization. During chromatography, the hybrid

complexes containing mercury-treated mRNA are adsorbed on the column. The combination of these two chromatographic methods is now being used in our laboratory for isolation of DNA containing individual, mainly globin, genes.

#### A Method Based on Production of P-Loop Structures

This method as such has not yet been refined for isolation of genes, but we have the interesting finding of R. White and D. Hogness that, under specific priming conditions, ribosomal RNA is hybridized with native DNA. The comprehensive studies of R. Davis et al.<sup>10</sup> revealed that, under these conditions, RNA ejects the homologous DNA chain and structures are formed, which have been named P loops. These structures are formed at a temperature that induces partial denaturation of DNA because of the greater thermodynamic resistance of RNA-DNA hybrids. H. Westphal et al.<sup>11</sup> observed formation of P loops under an electron microscope, in hybridization of adenoviral mRNA with native DNA. In principle, it is promising to use this hybridization technique with subsequent chromatography of the hybrids as described, for example, in the preceding section for isolation of structural genes.

In conclusion, it can be stated that development of the techniques described here, as well as others yet to appear, will enable us to obtain a number of eukaryote genes, in sufficient quantity for experimentation, in the near future.

This would make it possible, first of all, to undertake studies dealing with identification of their primary structure. For example, we have learned (at the conference in Miami, 1977) that Maniatis et al.<sup>12</sup> made a complete identification of the gene that codes rabbit beta-globin, which they synthesized in 1976. In view of the enormous progress made in methods of analyzing primary DNA structures, we should discuss future achievements in this field, and they will definitely result in solving a number of basic problems of molecular biology and molecular genetics. We can expect substantial progress in this direction, with regard to solving the basic problems of molecular biology and molecular genetics.

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## GENETICS

UDC: 576.851.513.098.396.332.095.57

### HETEROLOGOUS TRANSFORMATION IN BACILLUS SUBTILIS REPORT 1. TRANSFER OF PLASMID Rldrd19 DNA

Moscow ZHURNAL MIKROBIOLOGII, EPIDEMIOLOGII I IMMUNOBIOLOGII in Russian No 5, 1977 pp 33-37

[Article by L. S. Naumov, V. K. Numerov, A. N. Bozhko, A. A. Lushnikov, V. S. Tyurin and I. V. Domaradskiy, All-Union Scientific Research Institute of Protein Biosynthesis, Moscow, submitted 20 Sep 76]

[Text] *Bacillus subtilis* produces several antibiotics and enzymes that are of interest to medicine and the microbiological industry. The roster thereof could be substantially augmented if we had effective methods for controlling inheritance in this microorganism, rather than remain content with spontaneous mutants as producers.

The important distinction of *B. subtilis* is the spontaneous capacity for genetic exchange by means of transformation. This opens up vast opportunities for determining the possibilities and limitants of transfer of genetic information from one species of microorganisms to another by means of isolated DNA molecules. The practical importance of such "heterologous" transformation can be illustrated, if only by the fact that production of neutral protease by *B. subtilis* is substantially increased under the influence of DNA from *Bac. natto* [6], and that of  $\alpha$ -amylase under the influence of DNA from *Bac. subtilis* var. *amylosacchariticus*.

We first discovered [1] the possibility of transforming *B. subtilis* by means of DNA from R plasmids referable to *B. aeruginosa* and *E. coli*. In this article, we submit comprehensive data on transformation of *B. subtilis* by purified preparations of *E. coli* plasmid DNA determining antibiotic resistance.

In selecting R factors, we were governed not only by the fact that they had a wide range of hosts and carried convenient selection markers (Table 1), but by the desire to facilitate industrial processes by addition of antibiotics to remove extraneous microflora.

Required amounts of DNA from plasmid Rldrd19 of *E. coli* J-53 were obtained by the method of Humphreys et al. [7]. This method makes it possible to isolate plasmid DNA that is minimally contaminated by fragments of chromosomal DNA. We assayed the DNA concentration by the method described by Burton [3].

Table 1. Characteristics of bacterial strains

Bacterial species and strain	Distinctive features of strains
<i>E. coli</i>	Incapable of growth without proline and methionine
J-53(Rlrd19)	Resistant to streptomycin, kanamycin, chloramphenicol, ampicillin and sulfamides
<i>B. subtilis</i> , SB-25/R	Prototroph. Chromosomal type of resistance to kanamycin and streptomycin
168 (BD-25)	ade 16 met B5 leu 8 nic 38
39-22	leu his <sub>2</sub> ind
168	ade 6 met B5 leu 8

We used *B. subtilis* strain No 168 (BD-25) as the recipient in the experiments dealing with transformation. It had been shown previously that strain No 168 does not carry cryptic plasmids [9].

A competent culture was obtained by the method of Anagnostopoulos and Spizizen [2]; it was then frozen in 15% glycerin solution and stored at  $-40^{\circ}$ . We confirmed the fact that the culture reached a competent state by means of homologous transformation. We bred transformants on the basis of ability to grow without adenine, leucine or methionine. As a rule, there was a rather high frequency, of the order of  $10^{-3}$  of transfer of the markers in question.

As we know, the frequency of transformant production in experiments with heterologous DNA is much lower than with homologous DNA. Bearing this in mind, and to increase the probability of demonstration of transformants, which could not be high enough even under our conditions, we tested several methods of setting up experiments for transformation of antibiotic resistance (we tested conditions by means of chromosomal DNA isolated from mutant SB-25/R, which is resistant to streptomycin and kanamycin). Ultimately, our choice was the method of Goldberg et al. [5]. We shall describe it in the form we used to work with plasmid DNA. After incubation for 30 min, a mixture of recipient cells and DNA was passed through HAWP (Millipore) filters, with mesh size of  $0.45 \mu\text{m}$ . The filters were put in dishes with 0.7% Spizizen agar enriched with yeast extract (0.5%, Merck). After 3.5 h, the filters were transferred into dishes with the same medium, but with added antibiotics ( $10 \mu\text{g/ml}$  kanamycin,  $250 \mu\text{g/ml}$  streptomycin).

With this method, we succeeded in transformation up to a mean frequency of  $2.4 \times 10^{-6}$  per  $\mu\text{g}$  DNA (Table 2). Each time, 50 to 150 colonies developed on the filters, and they were resistant to streptomycin and kanamycin. Of the 50 selected clones, 20 were capable of growing in liquid and solid media containing kanamycin in a concentration of  $20 \mu\text{g/ml}$  and streptomycin in a concentration of  $250 \mu\text{g/ml}$ ; 12 could grow in the presence of  $40 \mu\text{g/ml}$  kanamycin and  $500 \mu\text{g/ml}$  streptomycin; the level of resistance of the rest of the clones corresponded to the concentration of both antibiotics in selective medium.

We should mention that the transformants retained adenine, leucine and methionine dependence inherent in the recipient (which indicates absence of contamination), there was a relatively high frequency of transformation, higher than in previous experiments [1] and no resistant clones were found in control tests (without DNA).

Table 2. Results of experiments on transformation ( $2.6 \times 10^7$  cells of recipient strain BD-25 were plated with antibiotics)

Experiment No	Concentration of Rldrd19 plasmid DNA, $\mu\text{g}/\text{ml}$	Number of transformant colonies	Frequency of transformation scaled to DNA, $\mu\text{g}/\text{ml}$
1	1.5	100	$2.6 \times 10^{-6}$
2	1.5	150	$3.8 \times 10^{-6}$
3	3.0	55	$0.9 \times 10^{-6}$

We submit below evidence of the fact that antibiotic resistance is indeed related to acquisition of plasmid DNA by recipient strains.

The selected cultures of transformants were incubated in liquid medium with kanamycin and streptomycin in the presence of  $^3\text{H}$ -thymidine ( $2.5 \mu\text{Ci}/\text{ml}$ ). Cleared lysates were obtained by the above-mentioned method [7], and plasmid DNA was isolated, bypassing the stage of polyethylene glycol treatment. Analysis of DNA in a density gradient of cesium chloride with ethidium bromide revealed a satellite DNA peak in several transformants (Figure 1). There was no such peak in recipient strain BD-25.

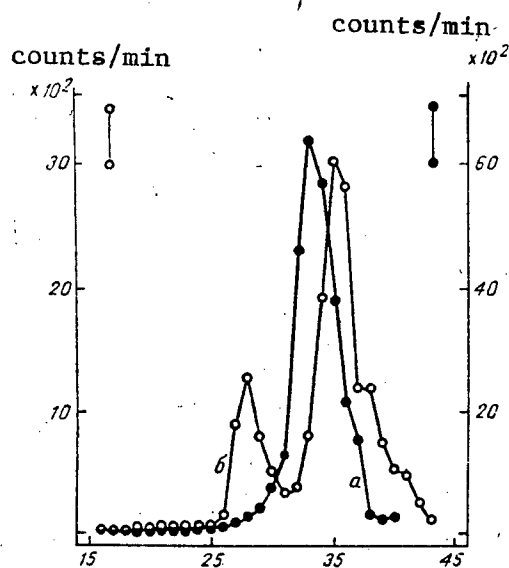


Figure 1.  
Sedimentograms of "cleared" lysates in cesium chloride. X-axis, fraction number  
a) recipient *B. subtilis* strain BD-25 labeled with  $^{14}\text{C}$ -thymidine ( $0.25 \mu\text{Ci}/\text{ml}$ )  
b) transformant *B. subtilis* strain No 49 labeled with  $^3\text{H}$ -thymidine ( $2.5 \mu\text{Ci}/\text{ml}$ )

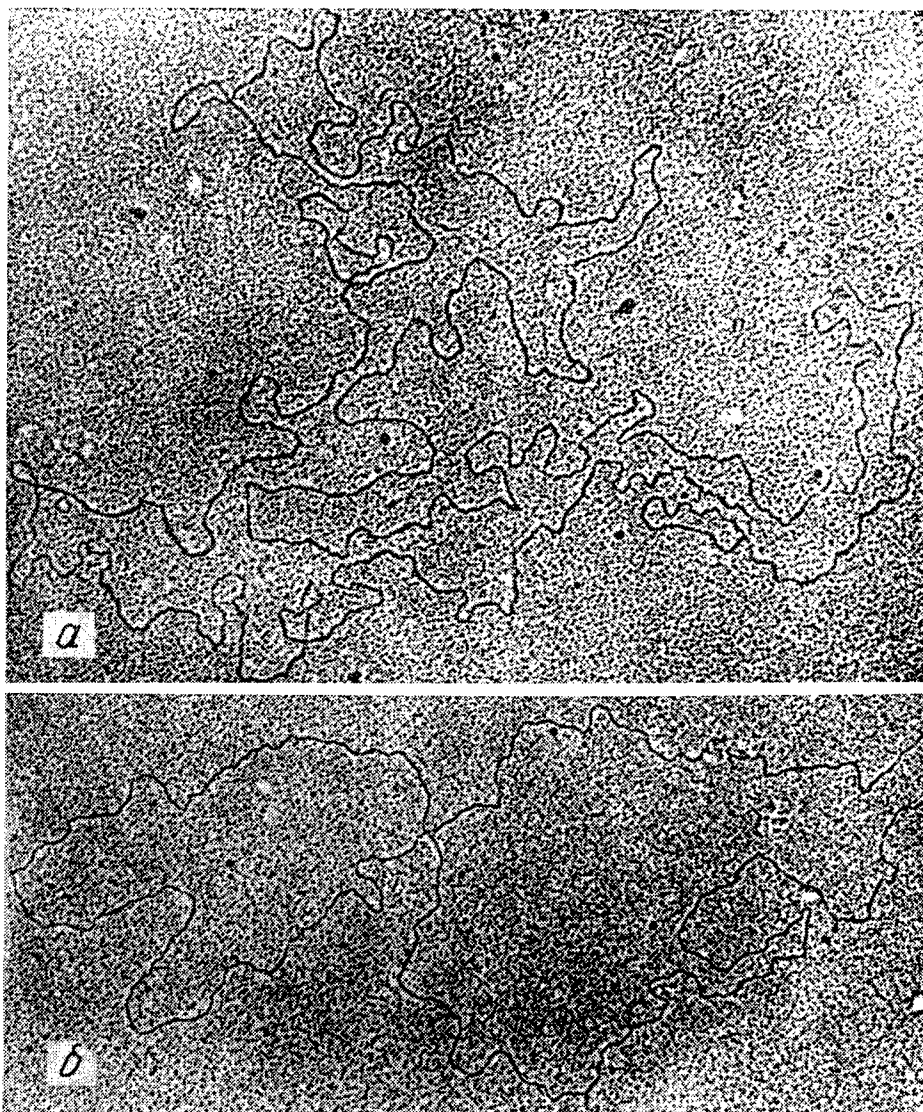


Figure 2. Electron microphotographs

- a) DNA of plasmid Rldrd19 isolated from *E. coli* strain J-53
- b) DNA of a plasmid isolated from *B. subtilis* transformant strain No 49

We treated cells of recipient *B. subtilis* strain BD-25 with the preparations of plasmid DNA isolated from transformants. This resulted in appearance of new transformants resistant to kanamycin and streptomycin.

Finally, using temperate phages AR9 and PBS1 reproduced on the transformants, we succeeded in transferring resistance to both antibiotics to *B. subtilis* strains Nos 168 and 39-32. The mean incidence of transduction constituted  $1 \times 10^{-5}$ .

For electron microscopy, the preparations of plasmid DNA were treated by the method of Kleinschmidt [8]. We determined the size of plasmid DNA by measuring the contour length of "open" forms of DNA on photographs (Figure 2). It was determined that plasmid DNA isolated from a typical *B. subtilis* transformant (No 49) had a length of  $19.9 \pm 0.7 \mu\text{m}$ , which corresponded to a molecular weight of  $41.3 \pm 1.5$  megadalton. The DNA of plasmid Rlrd19 from *E. coli* strain J-53 had a molecular weight of  $63.5 \pm 2.0$  megadalton ( $30.7 \pm 0.9 \mu\text{m}$ ), which is consistent with the data in the literature [10].

Analysis of plasmid DNA from the same transformant in a neutral saccharose density gradient was performed by the method of Clewell and Helinski [4]. The sedimentation coefficients of "closed" and "open" forms of plasmid DNA were found to constitute 64S and 43S, respectively (the sedimentation coefficient of the open form of plasmid Rlrd10 DNA was 51S). From the sedimentation coefficient, we calculated the molecular weight of transformant plasmid DNA, and it constituted 41.7 megadalton.

According to the characteristics of *E. coli* strain J-53 (see Table 1), plasmid Rlrd19 gave it, in particular, resistance to kanamycin, streptomycin and chloramphenicol. The plasmid should have transmitted the same characters to *B. subtilis* transformants.\* Two of them, resistance to kanamycin and streptomycin, were indeed transmitted, but we failed to demonstrate the third, chloramphenicol resistance, in any instance. Comparison of these findings to the results of electron microscopy suggests that perhaps plasmid Rlrd19 lost some of the genetic determinants after penetration of DNA in the cell, or else within *B. subtilis* cells.

In spite of our expectations, insertion of plasmid Rlrd19 in *B. subtilis* had little effect on its nonselective properties. At any rate, electron microscopy of recipient strain BD-25 and transformants failed to demonstrate any differences whatsoever in cell morphology. As before, there was retention of sensitivity to phages SP01, SP50, PBSI, AR9, AR3 and AR1, which is specific to *B. subtilis*, and no sensitivity to phages  $\lambda$ , f2 and P1 of *E. coli*. There were only some differences in biochemical properties of the transformants: some fermented glucose, mannitol and glycerin to a lesser extent. We observed retarded growth of transformants in liquid and solid media, due to extension of the lag phase.

Follow-up on the transformants has already lasted over a month. They remain resistant to kanamycin and streptomycin, as they were when we obtained them. Elimination of this character, if it does occur, happens very rarely.

In conclusion, it should be noted that the feasibility of transforming *B. subtilis* by means of plasmid DNA opens up wide opportunities for investigation of the distinctive features of phenotypic expression of foreign genes in a new host.

\*In addition, the transformants could acquire two more characters: resistance to ampicillin and sulfamides. However, we did not determine the reaction to ampicillin, since the recipient strain is resistant to it, while sulfamides were not used because of the lack of appropriate media.

## Conclusions

1. *B. subtilis* was submitted to genetic transformation by means of plasmid Rldrd19 DNA from *E. coli*; the physicochemical characteristics of the transformed plasmid have been defined and its molecular weight determined (4.13 megadalton).
2. Retransformation of resistance to antibiotics was performed on the model of *B. subtilis* strain BD-25, using plasmid DNA isolated from transformants, as well as transduction thereof by phages AR9 and PBSI.

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## PLANT PATHOLOGY

### THEORETICAL BASES FOR CONSTRUCTING SYSTEMS OF CONTROL MEASURES FOR INFECTIOUS DISEASES IN PLANTS (FOR EXAMPLE: COMMON MOLD IN SPRING WHEAT AND BARLEY)

Novosibirsk SIBIRSKIY VESTNIK SEL'SKOKHOZYAYSTVENNOY NAUKI in Russian No 6, 1977 pp 42-48.

[Article by V. A. Chulkina, candidate of biologic science]

[Text] An ecological approach to regulating the relationship between pathogen, plant and surrounding environment is, at the current stage of agricultural development, one of the leading methods for an integrated approach to protection of plants from infectious diseases. It provides an in-depth understanding of the natural development of plant diseases and, first and foremost, gives insights into the nature of their epiphytotic process as a complex biological phenomenon, the origin and course of which in natural conditions is determined by different objective principles.

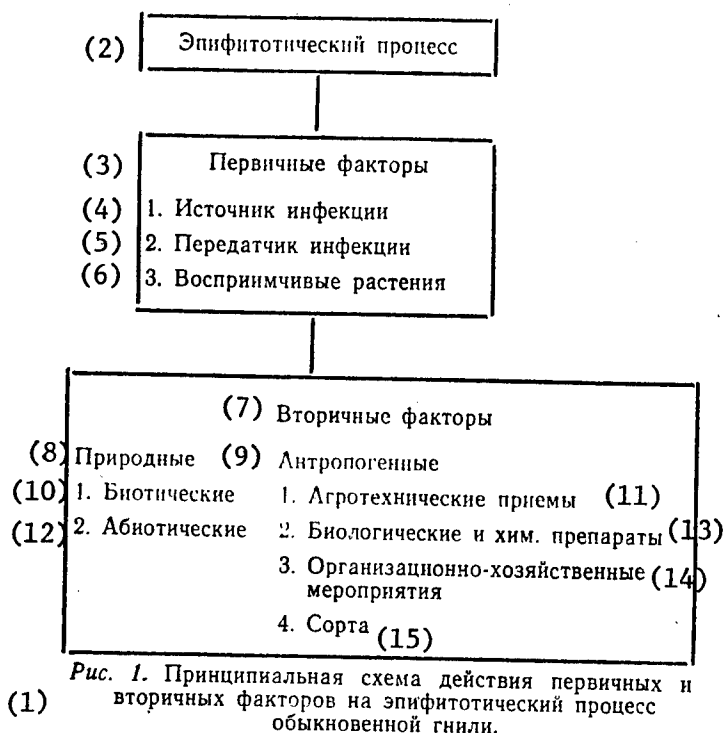
Pursuit of these studies will enable the establishment of general epiphytology as an independent science concerned with objective principles of the origin, development, and interruption of the epiphytotic process as well as with methods suitable for conditions in Siberia for prevention and elimination of the process. This direction of research requires review of certain established methods and the development of new methodological approaches and concepts.

In the narrowest sense, the elucidation of the nature of these diseases requires an examination of their lineage in evolutionary terms. Pathogens for common mold have been in Siberia for a long time--the fungi of *Bipolaris sorokiniana* (Sacc.) Shoemaker [syn. *Helminthosporium sativum* Pam., King et Bakke, ascomycetous stage--*Cochliobolus sativus* (Ito et Kuribay) Drechs.], *Fusarium oxysporum* Schlecht, *F. avenaceum* (Fr.) Sacc., *F. graminearum* Shwabe have caused diseases continually in spring wheat known in the literature under the names of "black buds," "fusarium," and "root mold." The current research of E. E. Geshele, F. P. Shevchenko, P. G. Alinovskiy, and A. N. Dobretsov is concerned with this topic as was the earlier work of K. Ye. Murashkinskiy and I. N. Abramov [1-6]. The latter authors considered that parasitically induced diseases in grain crops date from the beginning of agricultural crops in Siberia and in the Far East.

Reviewing our own data and data in the literature, we conclude that the most important feature of the epiphytotic process of common mold in spring wheat and barley is its continuity in time and space. Repetition of the development of the disease from one vegetative period to another serves as an external manifestation of this continuity. This supports the opinion that in the process of the evolution of the relationship between pathogen, plant and environment, relatively constant factors developed which guaranteed the safety of the given operational system in the natural conditions of Siberia and the Far East. In this regard, the separation of primary factors, formed during the process of evolution as a necessary adaptation by the pathogen to its parasitic state in living plants from secondary factors of the environment has essential and important significance (Figure 1).

**Key:**

1. Figure 1. The basic diagram of the effect of primary and secondary factors on the epiphytologic process of common mold. 2. Epiphytological process 3. Primary factors 4. Source of infection 5. Transmitter of infection 6. Susceptible plants 7. Secondary factors 8. Natural 9. Man-induced 10. Biotic 11. Agri-cultural-technical modes 12. Abiotic 13. Biological and chemical preparations 14. Organized farm control measures 15. Variety



Three topics comprise the primary factors of the epiphytotic process: the source of infection (more precisely, source of the disease pathogen), the transmitter of the infection (transmitter of the disease pathogen), and the susceptible plants. Given the uninterrupted function of all three primary factors in natural conditions, the epiphytotic process spontaneously occurs. But, on the other hand, by removing one link in the chain of primary factors, the epiphytotic process of any infectious disease, including common mold, cannot occur.

The pathogen is active from the onset of the relationship between pathogen, plant and environment. Therefore, preventing the onset of the epiphytotic process of any infectious disease entails, in essence, interrupting continuity of the pathogen's life cycle. Academician Ye. N. Pavolskiy considered this principle fundamental. Its application and development was concerned initially with transmission of infection but was applied subsequently

to infectious diseases in man and animals and led to the elimination of a number of epidemics and epizootics. This principle is applicable primarily to the phytopathology of virus diseases [8]. The creative development of the general biological ideas of Ye. N. Pavlovskiy relevant to phytopathology was first begun by M. V. Gorlenko [9, 10].

The most radical means of battling plant diseases is to produce resistant types. In this manner if the "susceptible plants" link in the chain of primary factors is removed, and the epiphytotic process of an infectious disease is interrupted. However, in a number of diseases, including common mold, definite resistant varieties have yet to be identified. Because of this, the question naturally arises: is it possible to achieve interruption of the epiphytotic process by other means such as removing the source or transmitter of the infection from the chain of primary factors?

Before responding to this question, one should pause to define the concept of "source of infection" and "transmitter of infection," because the correct understanding of these terms has theoretical and practical significance.

In the phytopathologic literature, the opinion has taken hold that the source of infection can be "living diseased plants and their parts which have been infested or contaminated by the relevant fungus (seeds, tubers, bulbs, stalks, seedlings and whole plants), vegetable remnants separated from plants, vegetable raw materials and so forth (leaves, fruit, stubble, bark shavings, pieces of wood and others), and finally, anything which comes in contact with the diseased plant and its parts directly or through other agents which have been infested or contaminated (soil, agricultural tools, man, animals, water, air, and others) [11]. Roughly the same definition of the source of infection is encountered in works of other authors. It is evident that in the phytopathological literature the distinction between concepts of "source of infection" and "transmitter of infection" is not made. They are both used to connote "source of inoculation." Nevertheless, this contradicts the theory of parasitism. Indeed, it is known that during the evolutionary process pathogens for infectious diseases in plants adapted to a parasitic state in living plants at a high price--loss of the characteristics of the common saprophyte. It is well known that parasites cannot successfully compete with saprophytes in the struggle for a nourishment source outside the living plant. *B. sorokiniana*, one of the pathogens of common mold in grain crops, serves as an example.

This pathogen is very sensitive to saprophytic and antagonistic microflora and in general to soil fungistasis [12]. According to current concepts, it cannot grow or develop spontaneously in the soil, but is preserved in it only for a course of 3 to 5 years [13]. The soil is an alien environment for the pathogen where it must fight for its existence until that time when it can successfully grow and develop in susceptible plants. Therefore, it is erroneous to consider soil and plants as equivalent objects for the vital activity of the fungus: the first can serve only as a transmitter, whereas the second is the source of infection. Studies concerning the sources

and transmitters of an infection were elevated in medicine to the level of scientific law [14]. It is necessary to elevate studies in phytopathology to the same level.

What is a source of infection? A source of infection is an object which serves as the place for the natural residence, reproduction and accumulation of the pathogen and from which the pathogen can, by one or another means, infect other organisms. For example, the primary sources of infection for common mold are the diseased plants of spring wheat and barley. In Siberia additional sources of infection can be seta, wild oats, hemp, rhizome grass and others. Unfortunately, however, the role of every biological host as a source of infection for pathogens has yet to become a subject for detailed investigations.

During the parasitic stage an intense accumulation occurs, initially of a vegetative mass, followed by pathogen reproduction and subsequent pathogen shedding in the environment. According to experiments which we have conducted in premountainous and other zones in Siberia, accumulations of the biomass and conidium of *B. sorokiniana* in spring wheat and barley plants infected with common mold are fixed in this way. The shedding of the conidium in the soil under the foliage of the diseased plants and in the air occurred during the entire course of vegetation, reaching a maximum toward the end of the vegetative period, particularly in damp, warm weather. This period for maximum accumulation of common mold pathogens in spring wheat and barley crops is confirmed by all practicing farmers in Siberia and at the present time is not subject to doubt. We attempted merely to give this fact a theoretical foundation.

Unlike the source of infection, the transmitter of infection is an object which serves as a place in nature for residence and conservation of the pathogen, guaranteeing its transmission from the source of infection to healthy plants. According to L. V. Gromashevskiy [14], the mechanism for the transmission of any infectious disease consists of three sequential stages: 1) shedding of the pathogen from the diseased organism, 2) residence of the pathogen in the environment, and 3) implantation of the pathogen in the new organism. It is considered that in the course of evolution each pathogen adapted a distinct mechanism for transmission from one to another generation of biological hosts. In his time, E. Goyman noted the immense importance of this condition for the fate of infectious diseases in plants: "All infectious diseases can be spread from diseased plants to healthy ones; otherwise the disease would end its existence with the death of the diseased plant" [15]. Although subsequently this position was confirmed by a multitude of data, it did not obtain any theoretical foundation because, in our opinion, a systematic approach to the examination of such a complex biological phenomenon as the epiphytotic process was absent.

The transmission of the pathogen from one generation of biological hosts to another occurs through objects in the environment. Of particular importance is the fact that pathogens for various infectious diseases adapted

a distinct mechanism for transmission. Thus, the pathogen for common mold adapted a mechanism for transmission from the diseased plants of the previous year to the susceptible plants of the following year through its survival in soil and seeds [16]. It is known that in various ecologic-geographic zones of Siberia, the frequency of the pathogen's transmission both via soil and especially via seeds differs. Transmission of *B. sorokiniana* in the territory of Western Siberia occurs most frequently via the soil in the forest-steppe, steppe, premountainous, and mountain-steppe zones, whereas in the taiga and subtaiga regions this mode of transmission is noted to be four or five times less frequent. In the latter zones seeds are mainly responsible for transmission of the pathogen, whereas in the southern forest-steppe, and particularly in the steppe, the seeds have almost no practical significance.

At the foundation of our presumed theory about the epiphytotic process and a system for control measures for infectious diseases is the task of interrupting the cycle of primary factors by removing the weak link from their chain. In the phytopathologic literature this task for a system of control measures is commonly formulated according to long-standing tradition as exemplified by the following: the control system must be directed toward the creation of conditions favorable for plants and unfavorable for the disease pathogen. It is evident that such a formulation is general, passive and not specific enough. The specificity of the task formulated for a system of control measures against a single or group of infectious diseases inevitably arises from actual, essential differences in their epiphytology, which up to now, have been insufficiently studied. In the case of common mold, while not negating the importance of limiting the sources of infection and decreasing the susceptibility of plants to the pathogens, we conclude that a system of control measures must primarily guarantee interruption of the mechanism for transmission of the pathogen from the source of infection to susceptible plants.

Given this fact, in comparably moist zones (taiga, subtaiga, premountain) a system of control measures must primarily prevent the possibility of pathogen transmission via seeds in the steppe zone via soil, and in the forest-steppe via soil and seeds. In order to solve successfully these problems it is important to know the direction, duration and effectiveness of known control methods as well as "the spectrum" of future effects of methods not yet developed. In the present article our purpose is to show the direction of currently known control methods, for in the literature this question is not well covered. Moreover, the multitude of literature sources should be listed in which the role of agricultural techniques and other methods (as well as natural factors) are examined from a methodological point of view according to a diagrammatic representation of the epiphytotic process. Such an approach does not take into account the strategic task for a system of control measures--the alteration of primary factors of the epiphytotic process in order to interrupt their cycle.

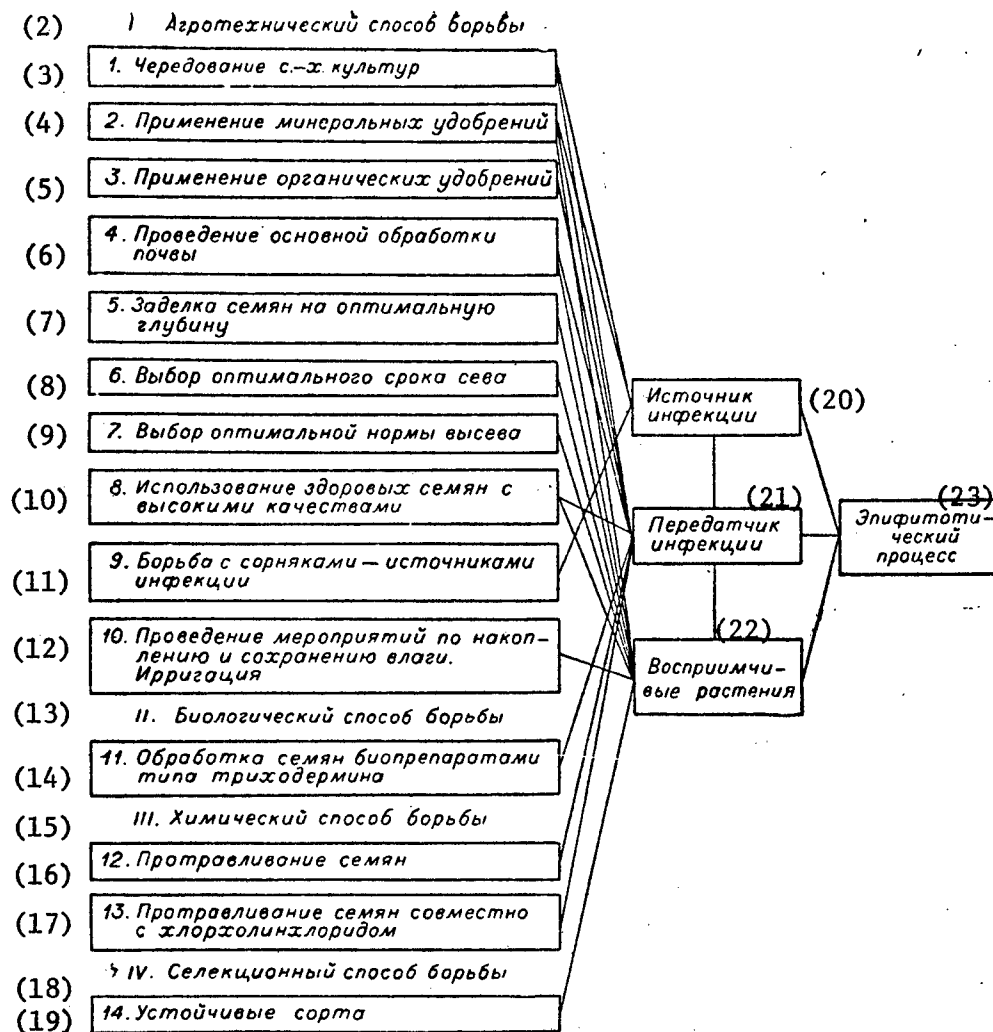
In contrast to secondary causes, primary factors affect directly the onset and intensity of the course of the epiphytotic process. The effect of secondary factors can only become apparent indirectly through the primary ones. Therefore, the presence of primary factors is a necessary condition for the development of any influence by secondary factors on the epiphytotic process.

Until recently, this position was clearly underrated. In our opinion control measures for diseases were insufficiently differentiated according to geographic zone, and usually were too general and passive in character. Because of this, the possibility of predicting or regulating the effect of the system of control measures was impossible.

However, secondary factors serve as means for implementing the strategic task of a system of control measures if their effect is considered in terms of the relationship between secondary factors, primary factors and the epiphytotic process, for secondary factors emerge with the repression or activation of primary factors. As a result of this we determined the direction of control measures by a diagram of the relationship between methods, primary factors and the epiphytotic process (Figure 2). In this way, the main effect on primary factors of methods which guaranteed a decrease in the level of intensity of the epiphytotic process was taken into account. This increases the value not only of their systematic but also purpose-oriented character. Of 14 methods studied, 3 exerted a direct or indirect influence on the source of infection, 8 on the transmitter of infection and 9 on the predisposition of the plant to the pathogens.

[Figure 2 and key on next page]

Figure 2.



(1) Рис. 2. Схема воздействия различных способов борьбы на первичные факторы эпифитотического процесса обыкновенной гнили.

Key: 1. Diagram of effect of various control methods on primary factors of the epiphytotic process of common mold. 2. Agricultural-technical control methods 3. Rotation of agricultural crops 4. Application of mineral fertilizers 5. Application of organic fertilizers 6. Conducting fundamental soil treatment 7. Planting seeds at the optimal depth 8. Selection of optimal period for sowing 9. Selection of optimal standards for sowing 10. Utilizing healthy seeds of high quality 11. Control of weeds—sources of infection 12. Conducting control measures for accumulation and retention of moisture. Irrigation. 13. Biological control methods 14. Treatment of seeds with biopreparation used for trichoderma 15. Chemical control method 16. Disinfection of seeds 17. Disinfection of seeds with chlorocholinechloride 18. Selective control methods 19. Resistant varieties 20. Source of infection 21. Transmitter of infection 22. Susceptible plants 23. Epiphytotic process.

Field experiments demonstrated that at the present time, a single method cannot interrupt the cycle of primary factors although it can assure a partial, statistically significant effect. Therefore, it is necessary to integrate rationally these methods and direct them toward removing the weakest link in the chain of the cycle of primary factors.

We presented the results of individual and combined control methods in earlier published works [16-17]. Here, we consider it important to emphasize that agricultural, technical and biological methods--which act on the soil as the main transmitter of the disease pathogen and in the environment, upon which depends to a significant degree the predisposition to the pathogen of the vegetating organs, particularly subterranean ones--are the leading methods for integrated protection of plants from disease.

The biological criterion for the effectiveness of a system of control measures is its ability to prevent disturbances in the formation of the crop's structural elements from the lower to higher stages of organogenesis, beginning with the first stage.

Testing of the stated theoretical suppositions in producing conditions in sectors of 40-500 hectares (the Zhulanskiy and Reshetovskiy sovkhoses, and the Elitnoye and Cherepanovskoye OPkh [Experimental Model Farms] of the Novosibirsk oblast) demonstrated their technical and operational effectiveness: the development of disease was lowered to 24.4-68.7 percent and the crop capacity was increased to 1-7 quintals per hectare (depending on the epiphytotic situation and the resources of the farm).

Thus, the theoretical bases for construction of a system of control measures for infectious diseases of plants rests on the study of primary and secondary factors of the epiphytotic process, which according to its objective natural principles has a continuous but uneven course in time and space.

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Processes in Agriculture

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MECHANISM FOR PHYSIOLOGICAL ACTION OF PHYSICAL FACTORS

Moscow VOПРОSY КУРОРТОЛОГИИ ФИЗИОТЕРАПИИ И ЛЕЧЕБНОЙ ФИЗИЧЕСКОЙ КУЛЬТУРЫ in Russian No 2, 1978 pp 1-6

[Article by R. Z. Amirov, Central Institute of Health Resorts and Physiotherapy]

[Text] The progress of medical science in our country has been governed by an improvement in social conditions, as well as by the development and introduction into clinical practice of new methods of diagnostics, treatment, and study of the mechanism of diseases.

If in the 1930-1940's clinical and physiological research used only electrocardiography, capillaroscopy, and arterial oscillography, then in the 1950's the number of medical diagnostic methods began to gradually increase. With an investigation of the electrical activity of the heart vectorcardiography began to be used, and further--topographical methods of studying the cardiac electrical field.

Thus we developed a technique for moment topography of potentials that made it possible to reveal many new laws governing the cardiac electrical field. Of them the primary was the circular motion of the dipole in the period QRS that served as the basis for the development of the technique for integral topography of the cardiac potentials. This technique, which is currently employed in 10 cities of the Soviet Union, is used for more precise diagnostics, especially of myocardial infarcts, and also for evaluating the effectiveness of rehabilitation measures for cardiac diseases.

In the investigation of the state of the cardiovascular system rheographic, impedance plethysmography techniques, ballistocardiography, polycardiography, and others have become widespread, and in the study of the external respiratory function--spirometry, pneumotachometry, capnography, and so forth.

With the development of methods for treating patients with ischemia bicycle-ergometric studies are being conducted which make it possible to evaluate the functional potentialities of the heart, as well as biotelemetry for control of cardiac activity during the fulfillment of therapeutic physical exercises and walking proportioned according to rhythm and duration.

Medical science and practice have been enriched with new techniques for diagnosing diseases of the nervous system (electro-, rheoencephalography, electromyography, stimulant electromyography, electromyotopography, and others). Present day health resort treatment and physical therapy have available also many other methods for studying the functional state of the patient's organism.

At the present time precise diagnosis of human diseases is not possible without the use of physiological and biochemical methods of research. Electronics has significantly expanded the resources for studying a patient, and conditions have appeared for conducting research in a considerably greater volume.

Physiological methods make it possible to quantitatively evaluate the degree of disorder in the patient's functions, and to determine the trend and degree of the physiological shifts under the influence of physical treatment factors. Analysis of the research results in turn serves as the basis for an investigation of the mechanism for the pathological process and the mechanism for the therapeutic action of the physical factors.

Clinical practice most often encounters patients with functional disorders of various physiological systems. These changes are a result of the pathological process. In investigating the pathophysiological mechanisms of the disease we pay attention to the most frequently encountered variants of functional disorders. Thus under the influence of a varying type of damaging factors the functional potentialities of definite organs are reduced. For example, during myocardial infarction the contractile function of the myocardium is drastically disrupted, therefore use of stimulating factors (physical, balneo-, and medicinal therapy, diet) is directed towards the development of compensatory potentialities of the myocardium. The factors that stimulate cardiac activity promote reinforcement and strengthening of the myocardial contractile function, while the dietotherapy and a number of medicinal preparations affect the main process--atherosclerosis of the vessels. Here the physical factors, due to their polytopic action, i.e., action on different functional systems of the organism, favorably affect both the restoration of the disrupted functions, and the main pathological process. The task of the physiologists, biochemists, and clinicians is to study the action of physical factors on the functional systems of the organism.

Another important feature of the mechanism for diseases is securing of the pathological state, despite the elimination of the causal factor. We view such securing as the result of fixation of the pathologically variable function according to the type of conditioned tonic reflex (R. Z. Amirov, 1956). It should be noted that conditioned tonic reflexes play a great positive role in the organism's adaptation to different conditions of human life, as well as in adaptation to diseases. The essence of conditioned tonic reflex consists of the fact that shifts in the level of functioning of the physiological system during its motor existence can be secured and maintained for a long time.

Securing of the changed level of any function is inherent also to healthy people. Study of the function of external respiration in 16 healthy men who were under piedmont conditions in the mountains of Tyan'-Shan' at an altitude of 2500 m above sea level for 14 and 30 days revealed its differences. The changes in external respiration that occurred after a 14-day stay under piedmont conditions within 45-47 days returned to the original (background) amounts, while after a 30-day stay in the mountains there was an increase in the functional potentialities of respiration which was manifest in the setting of a new level of the oxygen pattern that consisted of a saving in the energy processes, i.e., in the economical consumption of oxygen; it is especially important that these changes in the function of external respiration were preserved for a long time after the stay in the piedmont--45-47 days and over (R. Z. Amirov and Yu. A. Motorin).

A conditioned tonic reflex can also occur during a long pathological process, and preserve the developing functional shifts in homeostasis after the elimination of the causal factor. In this one can see also the inadequacy of the organism's reaction, i.e., securing of physiological reactions that are negative in nature. There are fairly many examples of this.

Thus in the investigation of external respiration in patients with chronic nonspecific pulmonary diseases conducted by many authors, as well as by the colleagues of our department, different changes were established in disorders of pulmonary ventilation. It is known that treatment of such patients presents great difficulties. This is explained by the fact that treatment measures directed towards the pathological process can be effective at the present time, but this effect is often brief. The fact is that treatment measures do not eliminate the secured functional shifts, while the latter are a factor in the restoration of the pathological state. In therapy for chronic nonspecific diseases of the lungs a number of authors for the restoration of the function of external respiration use techniques of forced ventilation, a type of "massage" of the lungs which produces a positive effect.

Another example. Hypertonia often develops as a result of the repeating action of pressor factors. As Pickering notes, the lengthy increase in arterial pressure often has the tendency to be secured on a high level even after the disappearance of the primary pressor stimulus. It is quite natural that the formation of a conditioned tonic pressor reflex can be most probable, although organic changes here also can play the role of the aggravating factor. It is known that under the influence of sanatorium treatment with the action of therapeutic complexes the conditioned tonic reflex is weakened or disappears, and good results are attained with normalization of arterial pressure. This is observed at the health resorts of Chalpon-Ata (L. N. Kobritsova; M. I. Cherkis), Tskhaltubo (R. Z. Amirov and S. I. Chikovani) and many others.

A third example can be the spastic paralyses in children that develop for various reasons. The spastic state that appears at the birth of a child without modern therapy will result in the securing of a pathological state

also of the conditioned tonic reflex type, and can acquire a dominant nature. The negative value of such a reflector spasm is great since the formation of motor coordinated movements of the extremities is disrupted. The use of inductothermy that destroys the spastic dominant, and physiotherapy generating coordinated motor habits is directed towards different links in the pathogenetic chain, and produces positive results (I. M. Taipov). It is important to note that the earlier treatment is begun, the better the results since here conditions are created for preventing the development of organic changes on the background of functional disorders, and for improving the compensatory potentialities of the nervous system.

In studying the mechanisms for the functional disorders of the voice (aphonia, dysphonia) we advanced the hypothesis on the securing of the pathological state according to the conditioned tonic reflex type. A vocal disorder elicited by different reasons (laryngitis, vocal strain, etc.) can be secured and maintained for a long time as a functional shift in the regulation of the vocal function (R. Z. Amirov, 1956). The use of therapy guaranteed the rapid restoration of the coordinated vocal function.

A study in the department of clinical physiology of the institute of the mechanism for the action of physical factors using up to 20 clinico-physiological techniques and conducting up to 15,000 studies annually for a number of years made it possible to draw a number of conclusions on the physiological peculiarities of the action of treatment procedures. First of all it should be indicated that the physical factors affect all the physiological systems (polytopicity) to a varying degree and in different directions. From these differences in physiological shifts a spectrum of action for the physical factors is put together.

The specific nature of the action of physical factors is always determined by their physical (or chemical) properties and by that substrate to which the effect of these factors is directed. It is known that the physical factors realize their action by reflector means, thus involving the nervous and humoral mechanisms of regulation (A. N. Obrosov).

Under the influence of physical factors a reflector change occurs in the function of the heart and respiration, metabolism, and an effect is noted on the allergic, inflammatory, and trophic processes; when the receptors are affected an analgetic, or conversely, an irritative effect can be attained. Everything depends on the selection of the factor and its dosage. Of great importance is the functional state of the organism which mainly depends on the severity of the disease. In an investigation of the action of radon baths for atherosclerosis of different localizations according to the data of functional studies it was shown that the dosage of radon baths depends on the spread and severity of the atherosclerotic process. Thus in cerebral atherosclerosis in combination with hypertonia a favorable effect is shown by radon baths of low concentrations (20-40 nKi/l) while baths of high concentrations (80-120 nKi/l) had a negative effect according to physiological indices; in atherosclerosis of main vessels radon baths of these concentrations have a positive therapeutic effect (R. Z. Amirov et al., 1972, 1977).

In the selection of the treatment factor together with its favorable action it is necessary to take into consideration the possibility of a negative effect (different trend of action of physical factors). This was reflected in physical therapy in the development of indications and contraindications for prescription. In our work, in addition to the study of new physical factors we plan research directed at revealing the possible negative effect on the vital organs and functions.

In practice one must confront examples where in addition to a positive therapeutic effect there are negative physiological changes that often do not have a harmful value and are completely permissible, i.e., the "fraction" of favorable action dominates here.

The different trend in the action of physical factors on different functional systems can be a manifestation of the specific nature of the factor employed or can depend on the original functional state of the patient's organism. Thus M. N. Zhil'tsova in the investigation of the effect of yellow turpentine baths on patients with atherosclerotic occlusions of main vessels showed that with a normo- and hypokinetic type of hemodynamics the indices for the hemodynamics are normalized (R. Z. Amirov and M. N. Zhil'tsova). In the hyperkinetic type under the influence of the same factor an exacerbation is noted in the hemodynamic indices--the contractile function in the myocardium was reduced, and the peripheral blood resistance was increased. These data indicate the change in the trend of action of the treatment factor depending on the original state of the function, in the given case hemodynamics.

In studying the functional state of the organism of patients at the present time one can raise the question of the prognosis for the therapeutic action of physical factors. For this purpose one can proceed from either the nature of the physiological shifts in the studied function, or from the results of using pharmacological tests, or from the data for the action of the first therapeutic procedures.

An investigation under the conditions of the Crimea according to clinical and functional indices of the action of the broncholytic preparation alupent in patients with chronic nonspecific pulmonary diseases found that with a favorable effect of the preparation on the function of external respiration positive dynamics is noted also in the climatotherapy in combination with physical factors--TPC and others (R. Z. Amirov and K. K. Nikolaychuk). In these studies it was shown that under the influence of alupent in patients with functional changes in external respiration all the indices of spirometry are improved. These data indicate that the pharmacological test with broncholytic preparations can be used for predicting the effectiveness of climatotherapy.

Data on the predictive value of the first reaction were obtained for patients with acquired cardiac diseases of a rheumatic etiology according to the reaction to the first radon baths. An investigation of the acid-alkali state of the blood revealed that in those patients in whom the metabolic and respiratory alkalosis disappeared during the aftereffect of the first

procedure positive dynamics was observed also in the course of treatment (according to clinical data and indices of the acid-alkali blood state), while in patients with the development of metabolic alkalosis in the period of the aftereffect of the radon bath unfavorable results of treatment were noted (G. A. Yerokhina).

Study with the help of tachyoscillography of the reaction to the first carbon dioxide baths in patients with hypertonia revealed that in the presence of pronounced hyper- and hypotensive reactions the action of the treatment course is less favorable as compared to the patients in whom the indicated reactions were moderate (M. I. Cherkis). These data also indicate the prognostic value of the nature of vascular reactions to the first baths in patients with hypertonia.

Study of the tolerance for a physical load during bicycle-ergometric analyses of patients with ischemia indicated that in the case of low tolerance better results are produced by the use of radon baths of low concentrations (40 nKi/l), while for patients with a high tolerance favorable results can be obtained also with high concentrations of radon baths (120 nKi/l). Here it was established that the age of the patients is important: in patients younger than 60 the rehabilitation measures make it possible to achieve an increase in efficiency, and in patients over 60 it is increased considerably less (R. Z. Amirov and V. I. Danilov). Thus the age of the patients is important both for the prognosis and for the prophylactics of the disease and improvement in efficiency.

The question of the change in the nature of response reactions of the organism after a course of physiobalneoprocures is important. With a favorable effect of the physical factors most often the response reaction to the latter procedure is significantly weaker than to the first, which served as the basis for considering this as the result of adaptation to the action of the therapeutic factor. However in analyzing the results of the clinicophysiological studies we concluded that under the influence of a course of therapeutic procedures the reactivity of the organism mainly is altered. These shifts can vary: in some cases with normalization of the functional state the reaction to the physical factor is weakened, and for the organism the therapeutic procedure is no longer as loading as the first was. In other cases the nature of the response reaction is altered--according to some systems it is normalized, according to others it has not yet reached a normal level or can be negative. There are also such examples where by the end of treatment normalization of the disrupted functions has been attained, while in the last bath the response reaction is paradoxical, i.e., the procedure produces a negative reaction governed, most probably, by overdosage.

In conclusion it should be indicated that the functional shifts which appear under the influence of diseases in different physiological systems are maintained for a long time and can acquire a dominant nature, or be fixed on a pathological level according to the conditioned reflex type; they require in treatment also lengthy, multiple repeated action for the stable restoration of a normal level.

In this respect the physical and health resort factors are the most effective. The selection of the most adequate factor, its correct dosage, and sufficient length of action are important, and if necessary the repeated implementation of the course of treatment for the stable restoration of the normal level of functioning.

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TREATMENT AT NAL'CHIK HEALTH RESORT OF PATIENTS WITH VIBRATION DISEASE DUE TO THE ACTION OF GENERAL LOW-FREQUENCY PULSATING VIBRATION

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I LECHEBNOY FIZICHESKOY KULTURY in Russian No 2, 1978 pp 18-22

[Article by A. A. El'garov, Department of Propedeutics of Internal Diseases and Facultative Therapy of the Medical Department of the Kabardino-Balkarskiy University]

[Text] In recent years sanatorium-health resort treatment has begun to be extensively used for patients with vibration disease (V. N. Ayvazov; M. L. Berov; A. A. El'garov, 1971-1975, et al.).

Of all three forms of vibration pathology vibration disease as a consequence of the action of general low-frequency pulsating vibration is the least studied, and is rarely diagnosed in light of the low specificity of the pathological process and the insufficient attention of physicians to it.

We observed 102 patients (72 men and 30 women) in age from 30 to 55: 30 bridge crane operators, 22 tractor drivers, 22 excavator operators, 20 heavy truck drivers, and 8 bulldozer operators. During their work all of them were exposed to a set of unfavorable effects (inconvenient position, static effort, visual and nervous stress, meteorological conditions), whereupon the primary one was general low-frequency pulsating vibration (A. A. Men'shov, N. T. Timofeyeva; N. N. Gushchina; V. I. Chernyuk, et al.). The occupation record of the patients was 6-30 years, and the length of the disease--2-10 years. Twenty-three patients had the first stage of the disease, the first-second stage--51 patients, second stage--26 patients, second-third stages--one, and third stage--one patient. The leading syndrome in the patients was vegetative polyneuritis (in 54), peripheral angiodystonic syndrome (in 21), cerebral (in 14) angiodystonic, and lumbosacral radiculitis (in 13).

The incoming patients most often complained of pains in the arms (87.2%) and legs (64.7%), paresthesia in the hands and feet (60.7%), their chilliness (56.8%), unexpected paling of the fingers during cooling (20.5%), pastiness and sweating of the hands and feet (80.3%), asthenoneurotic symptoms (80.3%),

pains in the spine (62.7%), in the area of the heart (69.6%) and stomach (52.9%), and dyspeptic (64.7%) and genital (31.3%) disorders.

A neurological examination revealed certain motor disorders of the facial nerve (in 15.6%), nystagmoid fluctuations (in 7.8%), hyporeflexia (in 56.8%), hyperreflexia (in 22.5%), and axial reflexes--Bechterew's, Brach's, and Marinesco-Radovici's (in 22.5%), changes in sensitivity--pain (in 96%), vibration (in 97%), and temperature (in 94.1%). In 33.3% painfulness during palpation of the limb muscles was noted, reduction in the strength of the hands --in 82.3%, limited movement of the spine and its increased sensitivity to palpation--in 67.6%, symptoms of tension--in 17.6%, and coordination disorders--in 14.7% of the patients. Often signs of vasovegetative and trophic disorders were defined: acrocyanosis (in 61.7%), acrohyperhidrosis (in 86.2%), acrohypothermia (in 47.4%), pastiness of the hands and feet (in 46%), hyperkeratosis, worn condition of the skin pattern on the palms, and change in the nails (in 29.4%), positive tests for white spot (in 48%), and Pal' (in 25.4%) and Bogolepov's symptoms (in 50.9%). All of this indicated the primary affection of the peripheral section of the nervous system, disruptions in the regional blood circulation, and vegetative-trophic disorders.

In 76% sinus bradycardia and arrhythmia were noted, tachycardia, increase (in 62.7% decrease) in wave voltage, ventricular complex impression, flattening of the waves P and T, and reduction or increase in the interval S-T. An increase in arterial pressure was noted in 18.6%, a reduction in 9.8%, and asymmetry in 45% of the patients.

The different trend in the disorders in hemodynamics on the level of the capillaries and precapillaries was indicated by the disruptions in capillary circulation (spastic syndrome in 30.4%, spastic-atonie in 40.2%, atonic in 23.5%), and the reduction (in 47%) or increase (in 19.6%) in the skin temperature on the hands and feet.

Rheovasography of 66.6% of the patients revealed different disorders. For 40.1% of the rheograms signs of an increase in the vascular tonus and an reduction in blood filling were characteristic, while for 26.5%--signs of a decrease in vascular tonus and an increase in blood filling, which indicated the deficiency in peripheral blood circulation as a consequence of dissociated vascular disruptions on various levels of hemodynamics.

During analysis of the rheoencephalograms the reactivity of the cerebral vessels in the basin of the internal carotid arteries proved pathological in 35.3% of the patients. A "hypertonic" state of the cerebral vessels (reduction in elasticity and flexibility of the vascular wall, of regional blood circulation) was recorded in 28.4%, and a "dystonic" state (increase in elastic and tonic properties of the vascular wall, and in pulse hemodynamics) in 6.8% of the patients.

Algesimetry made it possible to determine the increase in thresholds of pain sensitivity in 92.1%, and a reduction in them (hyperesthesia)--in 7.9% of the patients (the latter mainly in cerebral angiodystonic syndrome and lumbrosacral radiculitis).

Pallesthesio- and thermoesthesiometry revealed disorders in the vibration and temperature sensitivity depending on the stage of the disease (respectively in 97 and 94.1% of the patients). An increase in perception time was found during electron-optic tachystoscopy in 91.1% of the patients; this indicated a reduction in the cortical neurodynamics and the dynamic equilibrium of the primary nervous processes.

The results of the conducted studies indicated a disruption in the peripheral and central links of the cardiovascular system; in the function of the skin analyzer and higher nervous activity which most often was manifest as antio-spastic, less often as angiodystonic disorders in regional hemodynamics, neurohumoral disregulation of cardiac operation, metabolic-dystrophic processes in the myocardium, and pathological shifts in the receptor apparatus.

Two treatment complexes were used. The first included nitrogen-thermal baths (temperature 36-37°C; duration 12-15 min) every other day, alternating with mud applications by the local-reflector technique (temperature 40°C ; length 10-15 min, 8-10 procedures). The second set consisted of bromine-iodine baths and mud applications by the same technique.

The first treatment complex was used for 48 patients, the second for 54. The selection of the treatment complex was governed by the primary affection of the peripheral nervous system and the presence of marked regional hemodynamic disorders in combination with local vegetative-trophic disruptions.

The effectiveness of treatment was judged by the change in complaints of the patients, the dynamics of the clinical manifestations of the disease, and the results of the aforementioned studies.

During treatment a balneopathological reaction did not develop in the patients. Already after three-five procedures the complaints diminished, primarily about pains in the support-motor apparatus, and of paresthesia. By the end of treatment the state of health of the patients had noticeably improved as indicated by the favorable dynamics of the disease symptoms. Thus the pain syndrome had disappeared from 25.4% and had decreased in 41.1%, neurovascular disorders--respectively in 23.5 and 37.2%, trophic and muscular changes--in 12.7 and 22.5%, asthenoneurotic manifestations--in 30.1 and 42.1%, and genital disorders--in 7.8 and 15.6% of the patients. Positive dynamics were also noted for the indices of instrumental studies: reduction in the frequency of pronounced pathological changes in the capillary hemodynamics and an increase in the number of normal capillaries ( $D < 0.05$ ), tendency towards restoration of the indices for skin temperature of the hands and feet ( $D < 0.01$ ), in the indices for the rheograms of the fingers, feet and head ( $D < 0.05$ ). This indicated the improvement in regional blood circulation under the influence of the treatment.

# Direct Results of Health Resort Treatment

(a) Преобладающий синдром	(b) Стадия заболевания	(c) Первый комплекс лечения				(d) Второй комплекс лечения			
		+++	++	+	-	+++	++	+	-
Вегетативный полиневрит (54) (e)	I	3	5	—	—	2	13	—	—
	II	—	8	1	—	—	15	3	2
	II—III	—	—	1	—	—	—	1	—
Периферический ангиодистонический (21) (f)	I	2	4	—	—	1	3	—	—
	II	—	4	2	1	—	1	2	1
Церебральный ангиодистонический (14) (g)	I	—	2	2	—	—	1	1	1
	II	—	1	1	2	—	—	1	2
Пояснично-крестцовый радикулит (13) (h)	I	3	2	—	—	1	1	—	—
	II	1	3	—	—	—	2	—	—
Всего: (i)									
abs. (j)		9	29	7	3	4	36	8	6
%		18,8	60,4	14,6	6,2	7,4	66,7	14,8	11,1

Note. In parentheses--number of patients.

## Key:

a. Dominant syndrome

b. Stage of disease

c. First treatment complex

d. Second treatment complex

e. Vegetative polyneuritis

f. Peripheral angiodystonic

g. Cerebral antidystonic

h. Lumbosacral radiculitis

i. Total

j. abs.

On the EKG signs appeared of normalization of the frequency of the rhythm of cardiac contractions, the processes of excitability and conductivity, feeding of the myocardium, reduction in the metabolic-dystrophic disorders ( $D < 0.05$ ), governed by restoration of the neurohumoral regulation and metabolic processes, and microcirculation in the myocardium.

Reduction in the reception time ( $D < 0.001$ ), a decrease in the thresholds of pain ( $D < 0.01$ ), vibration ( $D < 0.05$ ) and temperature ( $D < 0.01$ ) sensitivity after treatment indicated an improvement in the functional state of the central nervous system and the skin analyzer.

As a result of treatment (see table) a considerable improvement (+++) was achieved in 12.7%, and improvement (++)--in 63.8%, and a slight improvement (+)--in 14.8%; the state of 8.7% of the patients did not change (-).

Positive direct results were noted in all the patients with the syndrome of lumbosacral radiculitis, 96.3% of the patients with vegetative polyneuritis syndrome, 90.5% of the patients with peripheral angiodystonic syndrome, and 64.5% of the patients with cerebral angiodystonic syndrome.

The advantage of the first treatment complex is apparent from the table.

Study of the remote results of treatment indicated that improvement in the state of health was maintained up to 6 months in 10 people, up to 1 year in 19, up to 1½ years in 9, and over 1½ years in 6 patients. After 1-1½ months following treatment the state of four of the patients became the same as before treatment which was explained by the progressing course of the disease. Results of treatment of patients with the initial stage of the disease were maintained 1½ years, and with pronounced stages--6-9 months. Favorable results of treatment were maintained the longest of all in patients with lumbosacral radiculitis (18-20 months), and vegetative polyneuritis (16-18 months), and in patients with peripheral and cerebral angiodystonic syndromes of polyneuritis (respectively 6-8 and 3-5 months).

We made a study of the indices for the temporary disability of the patients for 1 year before and 1 year after treatment. It was noted that the number of patients who were put on the sick list was reduced 2.5-fold (before treatment 42, after treatment 17), the number of sick lists 4.1-fold (respectively 158 and 36), and the number of days of disability was dropped 2.7-fold (1036 and 372). All of this is still more proof of the effectiveness of treatment at the Nal'chik health resort of patients with vibration disease.

#### Conclusions

1. Effectiveness of treatment at the Nal'chik health resort (nitrogen-thermal or bromine-iodine baths in combination with mud applications) of patients with vibration disease as a consequence of diverse vibration depends on the pronounced nature of the pathological process, the dominant symptom complex, and the treatment complex employed.
2. Treatment at the Nal'chik health resort of such patients had a favorable effect on their work capacity, and promoted a reduction in them of the duration and frequency of temporary disability.

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INFLUENCE OF HEALTH RESORT TREATMENT USING ULTRAHIGH-FREQUENCY ELECTRICAL  
FIELD AND CENTIMETER-RANGE ELECTROMAGNETIC WAVES ON PERIPHERAL CIRCULATION  
AND VASCULAR REACTIVITY OF PATIENTS WITH VIBRATION DISEASE

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I LECHEBNOY FIZICHESKOY KULTURY in  
Russian No 2, 1978 pp 22-25

[Article by A. A. Shatrov, I. M. Sechenov Yalta Institute of Physical Methods  
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In patients with vibration disease as a consequence of the primary action of  
"local" vibration the leading clinical pattern is polyneuritis and angio-  
dystonic syndromes with dominance of symptoms related to a spasm in the  
peripheral vessels (Ye. Ts. Andreyeva-Galanina and V. G. Artamonova, E. A.  
Drogichina, et al.).

In the system of therapeutic and rehabilitation measures for this disease an  
important role belongs to the methods of physical therapy. Taking into con-  
sideration the peculiarities of the physiological action of the UHF electrical  
field and the UHF electromagnetic field, as well as starting from the patho-  
genesis and clinical pattern of vibration disease we had the basis for the  
assumption that the indicated factors will be effective in treating patients  
with this form of pathology.

In order to reveal the peculiarities of the effect of high-frequency electro-  
therapy on patients with vibration disease we used digital plethysmography in  
addition to other methods.

Studies were made with the help of the plethysmographic attachment "Tryodin"  
(Hungary) with pneumo-electric transformer. Plethysmographs of this type  
mainly record changes in the arterial component of the vascular reaction  
(V. S. Moshkevich), and the arterioles are the part of the vascular channel  
which are the most active in a vasomotor respect (V. V. Parin and F. Z.  
Meyerson). The amplitude of the pulse waves, or the volume pulse, is an  
important index that characterizes the peripheral circulation (V. V. Orlov;  
L. G. Okhnyanskaya). The size of the volume pulse gives an idea of the state  
of tonus of the arterioles and the blood flow in them: low oscillations  
indicate an increase, high--a decrease in the tonus of arterioles and small  
arteries of the fingers.

Plethysmograms were recorded from the fourth finger of the left hand in the beginning, middle and end of a 30-40-day stay of the patients in the institute clinic. During the first 2-3 days background plethysmograms were studied. As unconditioned stimulants cold ( $4^{\circ}\text{C}$ ) and breath holding were used, as conditioned--the words "I give cold."

Digital plethysmography was conducted for 287 patients with vibration disease (155 with the first and 132 with the second stage) and for 30 essentially healthy individuals (to determine the normal indices). The patients ranged in age from 30 to 50; there were 209 men and 78 women. The majority of them were workers in the machine building and mining industries--foundry cleaners, drillers, and tunnelers. The disease developed in them as a result of the primary action of "local" vibration transmitted through the hands.

For treatment a UHF electrical field or electromagnetic centimeter-range waves (CMW) were used with physical therapy and climatotherapy. A "UVCh-300" apparatus was used to direct the UHF electrical field either on the collar zone in the paravertebral position of the condenser plates 16 cm in diameter with an air gap 1-15 cm (63 patients), or on the palms (14 patients) with a low-heat dose lasting 10 min daily for a treatment course of 15-18 procedures. CMW with the help of the "Luch-58" apparatus were directed towards the collar zone (107 patients) or hands (56 patients); a rectangular illuminator (30x9 cm) was used with air gap of 8-10 cm, output power for exposure of the collar zone of 40 w, of the hands--40 or 20 w; procedures lasting 10 min were conducted daily, 15 per treatment course. In order to determine the value of the procedure length 21 patients were exposed to CMW in the collar zone for 15 min.

The control group contained 47 patients that were only given climatotherapy.

The treatment complex of all patients included morning hygienic and therapeutic gymnastics, proportioned walks, air baths with low and average cold loads (V. G. Boksha and B. V. Bogutskiy), sea baths ( $36^{\circ}\text{C}$  for 10 min every other day for a treatment course of 8-10 baths), and in the warm season--sea bathing with a weak cold load (water temperature not below  $21^{\circ}\text{C}$ ), general sun bathing with gradual increase in the dose of total radiation from 10 to 40-60 cal with REET not below  $18^{\circ}\text{C}$ . Sun bathing and swimming in the sea were prescribed in the second half of the patients' stay in the clinic after 10 of the aforementioned physical therapy procedures and execution of the corresponding studies.

Before treatment the volume pulse of the patients was reduced on the average to  $0.075 \pm 0.02 \text{ cm}^3$  per  $100 \text{ cm}^3$  of tissue (with norm of  $0.192 \pm 0.010 \text{ cm}^3/100 \text{ cm}^3$ ). Its amount was lower in the second stage of the disease than in the first stage (respectively  $0.069 \pm 0.003$  and  $0.080 \pm 0.004 \text{ cm}^3/100 \text{ cm}^3$ ;  $D < 0.05$ ).

Investigation of the vascular reactions to the action of unconditioned and conditioned stimulants indicated a certain shortening in the latent period--in the majority of patients it was less than 4 s (on the average  $2.94 \pm 0.07 \text{ s}$ ).

The overall length of the reaction to the cold stimulant differed little from the norm-- $25.15 \pm 0.60$  s; the vascular reaction to the conditioned stimulant was shortened ( $18.30 \pm 0.50$  s). The pronounced nature of the vascular reactions in the patients in the study of the effect of unconditioned stimulants was within the limits of the lower border of the norm; the reaction to the conditioned stimulant was reduced.

In the process of treatment the indices of plethysmography were clearly improved. The volume pulse was increased in all the patients on the average from  $0.075 \pm 0.002$  to  $0.111 \pm 0.002$   $\text{cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ), whereupon the dynamics was more favorable in the first stage of the disease than in the second stage; the increase was 0.45 and  $0.026 \text{ cm}^3/100 \text{ cm}^3$  respectively.

A more pronounced increase in pulse oscillations was noted in the patients who were exposed to the UHF electrical field in the collar zone and CMW in this zone (40 w, 10 min) and the hands (20 w, 10 min). Less favorable shifts were noted in exposure to large doses of CMW (hands--40 w, 10 min, collar zone--40 w, 15 min). Thus after exposure to the UHF electrical field in the collar zone in 32 patients with the first stage of the disease the volume pulse increased by the middle of the treatment course by  $0.028 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.01$ ), and by the end of it--by  $0.03 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ), and in 23 patients with the first stage of the disease--respectively by 0.023 and  $0.037 \text{ cm}^3$  per  $100 \text{ cm}^3$  of tissue ( $D < 0.05$  and  $< 0.01$ ). Under the influence of a CMW treatment course in the same zone the changes were more pronounced. Thus in 61 patients with the first stage of the disease the average amount of volume pulse was increased by the middle of the treatment course by  $0.46 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ), by the end of it by  $0.061 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ), and in 33 patients with the second stage of the disease by the end of the treatment course--by  $0.047 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ).

In patients of the control group a considerably smaller increase was noted in the volume pulse only by the end of the treatment course (with the first stage of the disease from  $0.082 \pm 0.008$  to  $0.103 \pm 0.009 \text{ cm}^3/100 \text{ cm}^3$ ;  $D < 0.05$ ), and almost unmarked in the second stage of the disease (from  $0.059 \pm 0.004$  to  $0.070 \pm 0.005 \text{ cm}^3/100 \text{ cm}^3$ ;  $D > 0.05$ ).

Simultaneously with an improvement in the peripheral circulation a positive dynamics was observed in the indices of vascular reactivity. This was most clearly manifest in the normalization of the previously disrupted vascular reactions determined by the depth of reduction in the level of the plethysmographic curve. The average amount of the vascular reaction to breath holding in all the patients by the end of treatment had increased from  $0.116 \pm 0.004$  to  $0.153 \pm 0.004 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ), to the cold stimulant--from  $0.114 \pm 0.003$  to  $0.143 \pm 0.004 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ), to the conditioned stimulant--from  $0.079 \pm 0.003$  to  $0.101 \pm 0.004 \text{ cm}^3/100 \text{ cm}^3$  ( $D < 0.001$ ). Intensification of the vascular reactions was more pronounced when the treatment complex included exposure to CMW and UHF electrical field in the collar zone, as well as CMW on the hand, especially in the first stage of the disease.

Changes in the duration of the latent period, phases of development and overall duration of the vascular reaction in the treatment process were insignificant. Statistically reliable differences in the dynamics of these indices were mainly observed in patients that were exposed to CMW. Thus in 61 patients with the first stage of the disease who were exposed in the collar zone the latent period of the reaction by the end of treatment had increased from  $2.74 \pm 0.10$  to  $3.29 \pm 0.12$  s ( $D < 0.05$ ), while in 33 patients with the second stage of the disease already by the middle of the treatment course it had increased from  $3.60 \pm 0.16$  to  $4.13 \pm 0.15$  s. The phase of development of the vascular reaction and its overall length changed little. Their reliable increase to unconditioned stimulants more often was noted in CMW treatment.

Our studies showed that when the treatment complex includes UHF and CMW electrotherapy, especially with the collar technique, in patients with vibration disease the volume pulse is increased which indicates the reduction in spasm of the arterioles, and an improvement in peripheral circulation. At the same time favorable dynamics of the vascular reactions to the action of unconditioned and conditioned stimulants is observed.

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ELECTROSTIMULATION OF MUSCLES IN COMBINATION WITH SANATORIUM AND HEALTH  
RESORT TREATMENT OF PATIENTS WITH AFTEREFFECTS OF TRAUMAS AND DISEASES OF  
THE SPINAL CORD AT THE SAKI HEALTH RESORT

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I LECHEBNOY FIZICHESKOY KULTURY in  
Russian No 2, 1978 pp 28-30

[Article by L. D. Potekhin, V. I. Gorbunov, and A. G. Stoporov, N. N. Burdenko  
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[Text] In the restoration of the motor functions in patients with after-effects of diseases and traumas of the spinal cord a significant role belongs to electrostimulation of muscles which is used in the sanatorium in combination with balneomud therapy, massage, physiotherapy (TPC), and other therapeutic factors of the health resort.

For the restoration of motor disruptions electrostimulation is widely used for the contraction either of individual muscles (B. Ye. Yegorov, Ya. M. Kots, Yu. Yu. Bredikis, T. F. Kolesnikov, V. I. Kay, N. Ye. Mol'skaya, et al.), or of a group of adjacent muscles with similar function. We conducted analytical electrostimulation of 427 patients and as a result noted a significant improvement in 11 (2.5%) and an improvement in 407 (93.1%) of them.

If a motor response is not successfully obtained from the affected muscles the use of the segmental technique is suggested (N. Ye. Mol'skaya, the essence of which consists of the primary stimulation of the muscle synergists located above the level of affection. With favorable dynamics of the electrodiagnostic indices (after six-eight procedures) combined electrostimulation of the muscles is conducted both above and below the level of affection. Further muscles that are innervated by the affected segments can also be involved in the motor response. Electrostimulation by such a technique was conducted on 693 patients as a result of which a significant improvement was noted in 21 (3.1%), and improvement in 636 (91.7%) of them.

Nevertheless at the health resort the technique of functional electrostimulation is widely used; it is based on the principle of electrostimulation of the polysynaptic reflexes. It is known that with affections of the spinal cord

as a result of trauma, the infectious-allergic process, and so forth, the number of affected muscles generally is considerable, and therefore the formation of an integral motor response from contraction of individual muscles is difficult.

Consideration for the peculiarities of eliciting polysynaptic reflexes with the help of electrostimulation makes it possible to obtain a motor response in the form of genetically determined concomitant operation of many muscles that is correctly distributed in time and space, and serves to produce a definite adaptive effect, i.e., for one stimulus a motor response appears with the participation of a considerable number of muscles, the form of which depends on its parameters and localization of application.

For restoration of the disrupted neuromotor functions the motor response was selected for the purpose of the maximum simulation and compensation for the lacking function. Most often the following forms of motor responses were elicited:

- 1) step-like effect when in response to the electrical signal applied to the corresponding receptor zone there is alternate bending and unbending of the legs simulating all the phases of stepping(jerk, bending, transfer, unbending of the leg, and its support);
- 2) flexor bending effect when in response to the electrical signal the feet and toes unbend, the crus and thigh bend which guarantees separation of the leg from the support;
- 3) unbending effect when in response to the electrical signal the leg unbends which guarantees its anterior transfer in the step and initial support;
- 4) orthostatic effect when in response to the electrical signal the talocrural, knee, and hip joints are locked, as well as the lumbar region of the spinal column with stress of the appropriate muscles which guarantees the erect position.

Thus consideration for the peculiarities of the production of inherent polysynaptic reflexes by electrostimulation can accelerate the instruction of important functional habits (standing, walking, sitting, etc.).

The necessary motor habits were developed as follows:

- 1) the form of the motor response that is capable of correcting the present disorders was defined;
  - 2) the number and localization of the receptor zones from which the necessary motor response is elicited are established;
  - 3) the parameters were found for the stimulating signal capable of guaranteeing involvement of the muscle synergists in the functionally important motor act.
- As a rule with relatively low energy of the signal individual muscles are

involved which are located in direct proximity to the stimulating electrode, but with an increase in the signal energy the muscle synergists were involved. The signal energy was altered through the amplitude, length and frequency in physiologically permissible limits. Electrostimulation was performed when the patient was sitting, standing, walking, as well as with proportioned mechanical therapy. Thus the patients participated in the formation of the motor habit which was then secured by physical therapy exercises.

Functional electrostimulation of movements was performed on 1127 patients as a result of which a significant improvement was noted in 106 of them (9.4%), an improvement in 978 (86.8%), and no improvement in 43 (3.8%) of the patients.

Electrostimulation was conducted with the help of UEI-1 apparatus, "Amplipul's-3T," and "Mioton-2M," skin electrodes made of silver-plated brass foil 1.5-2 cm<sup>2</sup> in area. The points to which the stimulus is fed were located, as a rule, in the zones of muscle attachment, as well as in the zones of the transition of the muscle belly into the tendon. The number of points to which the stimulus was fed comprised from 2 to 8. The procedure lasted 20-30 min daily; the course of treatment lasted 15-20 procedures.

The effectiveness of treatment was determined according to clinical, electromyographic, and electrodiagnostic indices, as well as by methods of biopathomechanics with the use of the procedure developed in the sanatorium for examining the motor functions in patients that need motor rehabilitation.

Electrostimulation was received by a total of 3500 patients in 38,851 procedures. Combined treatment (balneomud therapy, massage, physical therapy, medication) was given to 95% of the patients in addition to electrostimulation.

The results of restoration of the motor functions in our patients are as follows:

- a) 854 patients used the orthopedic testing unit, and of them 448 (52%) exercised in a knee support;
- b) 816 patients exercised in a knee support, of them 340 (41%) were trained to stand;
- c) 562 patients wore braces, of them 68 (13.5%) were transferred to walking with walkers, 104 (20.7%) were taught to walk with crutches;
- d) 430 patients walked with crutches, of them 82 (19%) were taught to walk with canes;
- d) of the 246 patients walking with canes 70 (28.4%) began to walk without support.

Thus inclusion of electrostimulation in the complex of sanatorium and health resort treatment of patients with aftereffects of traumas and diseases of the spinal cord for restoration of the function system of motion produces good results and deserves to be widely used in practice.

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1977

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DIRECT CURRENT IN THE COMBINED TREATMENT OF PATIENTS WITH INFLAMMATORY  
SUPPURATIVE DISEASES OF THE LUNGS

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I LECHEBNOY FIZICHESKOY KULTURY in  
Russian No 2, 1978 pp 44-46

[Article by A. V. Alekseyenko, S. B. Sokolov, L. I. Kobrin, V. N. Opalinskiy,  
and Yu. A. Lavrent'yev, Department of Thoracic Surgery of the I. M. Sechenov  
Yalta Institute of Physical Methods of Treatment and Medical Climatology]

[Text] Antibacterial therapy of patients with aggravated bronchiectatic  
disease, chronic pneumonia, abscesses of the lung as a consequence of the  
poor tolerance for antibacterial preparations, resistance of microbial flora  
to them, morphological changes at the site of the inflammatory focus, and  
so forth, is not always sufficiently effective (G. S. Lyan; Ye. M. Muravitskiy;  
V. I. Kukosh et al.; V. I. Struchkov et al.; and others).

M. M. Anikin and G. S. Varshaver, A. P. Parfenov, V. S. Ulashchik and I. K.  
Danusevich, I. V. Vigdorchik and G. Ya. Tselmin' have shown that with the  
help of physical factors (electrical field, UHF, diathermy, direct current)  
one can improve the results of treatment of patients with pulmonary diseases.  
However, the majority of these reports refer to treatment of chronic processes;  
the use of physical factors is considered contraindicated in the treatment  
of acute diseases, especially complicated with suppuration due to the danger  
of spread of the infection. Taking into account the favorable effect of  
direct current on the metabolic and immunological processes at the focus of  
affection, as indicated by V. S. Ulashchik and I. K. Danusevich, and A. P.  
Parfenov, we used it in combination with antibiotics for acute diseases of  
the lungs, and chronic diseases in the phase of exacerbation.

The purpose of our study was to investigate the effectiveness of the combined  
use of antibiotics and direct current for patients with acute and chronic  
pulmonary diseases in the phase of exacerbation. Here we started from the  
position that inclusion of antibiotics into this complex would suppress the  
infection and prevent its spread.

We observed 78 patients in age from 7 to 58. Sixty-four had bronchiectatic disease in the exacerbation phase; 14 had acute pulmonary abscess. The duration of the disease in patients with bronchiectatic disease ranged from 3 to 25 years; those with acute abscesses--from 10 days to 2 months. Exacerbation of the bronchiectatic disease was manifest by intensification of coughing and copious discharge of sputum, and by symptoms of suppurative intoxication (increased temperature, sweating, fatigue, pathological changes in the blood--rise in erythrocyte sedimentation rate, leukocytosis, neutrophil leukocyte shift to the left, increase in level of  $\alpha_2$ - and  $\gamma$ -globulin fractions, etc.). X-rays were used to detect in all the patients either the pneumonic foci sometimes merging into vast infiltrative shadows, or considerable peribronchial infiltration into the zone of affection.

The treatment complex for pulmonary abscesses in two of the patients consisted of internal drop administration of antibiotics, and for 12 patients they were administered into the pulmonary artery. The highest daily doses of antibiotics were used with regard for the sensitivity of microflora (streptomycin, monomycin, kanamycin, oleomorphocyclin, and others). Fifty-nine patients with bronchiectatic disease were given antibiotics intravenously, while 5 --into the pulmonary artery. In addition 22 of these patients were given microtracheostomy, while the others--other methods of bronchial hygiene (bronchial drainage, intratracheal infusion).

The technique of combined use of antibiotics and direct current was as follows: after injection into the vein or artery of a  $2/3$  or  $3/4$  daily dose of antibiotics the area of the chest (electrophoresis of different drugs) was exposed to direct current (APG-32 or APG-33 apparatus). Calcium chloride was most often used as an anti-inflammatory and desensitizing substance. Other resources were also used (euphylline, heparin, and others). Here two electrodes  $150\text{ cm}^2$  in area each were placed on the chest transversely to the zone of affection. The current density was  $0.03\text{--}0.05\text{ mA/cm}^2$ , the procedure lasted 30 min, and there were 10-12-14 procedures per treatment course. One of the following antibiotics was given intravenously: streptomycin (1-1.5 g), kanamycin (1 g), oleomorphocyclin (0.75-1 g), penicillin (2,000,000-3,000,000 active units per day), as well as other antibiotics dissolved in a physiological solution. Depending on the state of the patient, the degree of activity of the inflammatory process, and the tolerance the quantity of antibiotics administered was increased or decreased. To the solution of antibiotics 5000-10,000 active units of heparin and 50-75 mg of hydrocortisone were added. The rate of administering the antibiotics was 30-40 drops in 1 min. The total volume of solution administered was 150-200 ml.

Besides the indicated therapy disorders in the patients' protein and electrolyte exchange were corrected, and cardiac remedies and vitamins were given to them. The patients did therapeutic gymnastics.

Under the influence of such treatment the infiltrative symptoms rapidly were reduced in the lungs, the state of health improved more quickly, as well as the general condition (the increased body temperature dropped, the sweating disappeared, the appetite improved, etc.). In patients with bronchiectatic

disease at the start of treatment the emission of sputum was alleviated, and then its quantity was reduced. In patients with abscesses infiltration into the lungs was rapidly diminished--still before the destruction of lung tissue. In the presence of bronchial drainage the direct current promoted an increase in the amount of sputum emitted at the start of treatment due to the decrease in edema of the mucous membrane of the draining bronchi. Gradually the amount of sputum was changed, and from suppurative it became sputum crudum.

By comparing the results of treatment of patients only treated with antibiotics with the results obtained in the use of combined therapy (antibiotics and direct current) one can note the more favorable results in the second case. Thus, in all the patients with acute abscesses of the lungs positive results were obtained: in 12 recovery occurred with resorption of the infiltrate and closing of the cavity of destruction, and two were discharged with dry residual cavities. In all the patients with bronchiectatic disease favorable results were also observed: cessation or reduction in coughing and expectoration, resorption of the infiltrative-pneumonic foci in the pulmonary parenchyma and peribronchially.

We will cite an observation as an illustration.

Patient G., 51 years old, entered 16 January 1976 with complaints of extreme asthenia, sweatiness, increased body temperature, pains in the right half of the chest, and coughing with sputum. He had been sick for 10 days. He fell acutely ill. On the second day he was hospitalized in the pulmonary ward of the municipal hospital where a diagnosis of acute righthand pneumonia was made. He was treated with antibiotics intramuscularly and with sulfanilamides. Due to an exacerbation of the condition he was transferred to the thoracic department of the institute.

Upon entering his state was serious: body temperature 39.6°C, pulse 122 per 1 min, dyspnea, pale blue skin color, coughing with little sputum (20 ml). Percutaneously--shortening of the pulmonary sound to the right in front (between the second and fifth rib). X-rays found in the upper lobe of the right lung in projection of the third segment a vast infiltrative focus with fairly sharp contours (Fig. 1). Over this section the respiration is bronchial and weakened. Infiltration was not detected in a tomographic study of the cavity formations in the focal region. The data of bronchoscopy: opening of upper lobar bronchus drastically constricted due to pronounced edema of mucous membrane, lower and middle lobar bronchi without pathology. Blood analysis of 17 January 1976: Hb 12.5 g%, erythrocytes 4 million, leukocytes 18,800, serum 64%, plasma 9%, lymphocytes 21%, monocytes 5%; erythrocyte sedimentation rate 38 mm per hour. On 17 January according to the Sel'dinger technique a cardiac catheter was inserted through the right femoral vein into the right branch of the pulmonary artery. The following mixture of drugs was injected daily through a probe: 1.5 g of kanamycin, 20,000 active units of heparin, 50 mg of hydrocortisone, 20 ml of a 2.4% solution of euphylline, 0.5 ml of a 1:4000 solution



Fig. 1. X-ray of patient G. upon admission. A vast infiltrative shadow is found in the projection of the 3rd segment in the upper lobe of the right lung.

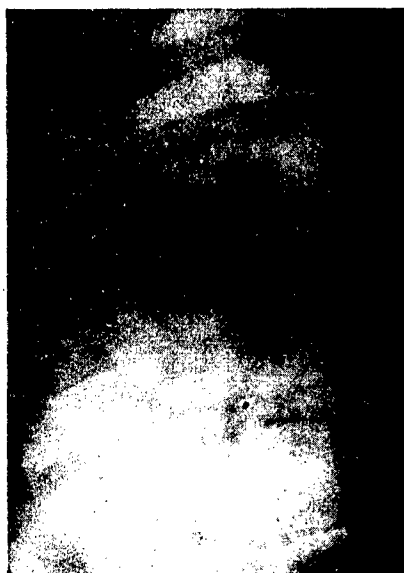


Fig. 2. X-ray of the right lung of the same patient 3 days after the introduction of antibiotics in the right branch of the pulmonary artery and galvanization in the region of the rib cage. The intensity of the infiltration has markedly decreased. The end of the probe, introduced into the right branch of the pulmonary artery, is visible.



Fig. 3. X-ray of the patient 3 weeks from beginning of treatment. Resorption of the focus of infiltration.

of strophanthin, and 1000-1200 ml of a physiological solution. The injection was given 24 hours a day by drops. During the administration of antibiotics treatment by galvanization was conducted daily on the right side of the chest in the area of projection of affection for 40 min. The patient's condition began to improve from the second day. By the sixth day the body temperature had become subfebrile, the sweating had disappeared, and the appetite had improved. On the x-ray photograph of 20 January, i.e., 3 days after the start of treatment, a sharp reduction was noted in the infiltrative phenomena (Fig. 2). The probe was removed from the pulmonary artery on the ninth day. Galvanization was replaced by electrophoresis of calcium which was conducted for 5 days. Antibiotics (kanamycin) of 1 g were administered intravenously until 2 February. Figure 3 (see the pasted inset) shows the x-ray photograph of 8 February 1976: at the site of the infiltrative phenomena in the right lung pneumosclerotic changes are visible. On 9 February 1976 the patient was discharged in good condition. He was examined after 3, 6 and 10 months. The good condition is being maintained and he is working.

We explain such a rapid resorbing effect by the use of antibiotics and direct current which is based on the principle of electroelimination--release of the antibiotics from the vascular channel into the pulmonary tissue and intercellular spaces. The same opinion is held by V. S. Balabukha-Poptsova and G. Ye. Fradkin, B. M. Broderson et al. By exposing specific sections of the lung to the electrical field of direct current one can create higher concentrations of antibiotics in the pathological focus which has a favorable effect on the effectiveness of treatment. Exacerbation or spread of the process did not occur in any of the patients with the use of direct current which we explain by the employment of fairly high doses of antibiotics.

### Conclusions

1. Combined use of antibiotics and direct current in patients with acute inflammatory suppurative diseases of the lungs produces positive results by promoting the rapid resorption of infiltrative foci in the pulmonary tissue.
2. This therapeutic action is based on the principle of electroelimination (release of drugs from the vascular channel into the tissues under the influence of direct current) and the more active effect of antibiotics on the pathogenic flora in the focus of affection.
3. The infection does not spread when direct current and antibiotics are used simultaneously.

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TREATMENT OF CHILDREN SUFFERING FROM PYELONEPHRITIS BY MEANS OF CENTIMETER-RANGE ELECTROMAGNETIC WAVES

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I LECHEBNOY FIZICHESKOY KULTURY in Russian No 2, 1978 pp 52-55

[Article by V. N. Gromova, G. I. Orlova, N. A. Korovina, L. S. Nikitinskaya, and V. N. Sennovskiy, Moscow Institute of Pediatrics and Children's Surgery of the RSFSR Ministry of Public Health, Nephrological Sanatorium No 9 of the Kuybyshev Rayon Health Department]

[Text] Treatment of children suffering from pyelonephritis, in addition to lengthy antibacterial therapy includes means of increasing the organism's resistance and promoting the restoration of the functional state of the kidneys (M. P. Matveyev, et al.). From these positions the use of physical factors is very important, in particular centimeter-range electromagnetic waves (CMW). In the literature we have found only the indication of their use for children with acute and chronic pneumonia, and for diseases of the liver and bile excreting passages (T. D. Zolkina; L. T. Stepanova; T. V. Karachevtseva et al.; and others). A positive effect of microwaves on the kidney function has been shown in the experiments of A. G. Subbota and A. S. Shatalina.

The use of CMW in pyelonephritis is governed by their pronounced anti-inflammatory and bacteriostatic action, and the favorable effect on the hemodynamics, oxygenation of blood and tissues, processes of cellular metabolism, and defense and adaptation reactions of the organism. The possibility for strict local, directed action on limited sections of the body and comparatively accurate dosing determine the indications for the use of UHF-therapy in pediatric practice.

We observed 108 children suffering from pyelonephritis in age from 5 to 14 who were under stage treatment in the local nephrological sanatorium. Primary pyelonephritis was in 87 of them, 21 had obstructive (after conservative and surgical correction of the obstruction). In only 1/3 of the patients the disease lasted up to 1 year, in the others it exceeded 3 years. Before entering the sanatorium all the children had received active antibacterial therapy for the last 3 months. Despite this the activity of the microbial

inflammatory process of the first-second degree was preserved in them (according to the classification of M. S. Ignatova and A. D. Reshetnikova, 1970). The majority of the patients had signs of intoxication (skin pallor, decreased appetite, rapid fatiguability), in 15 dysuric symptoms and pains in the stomach were noted. The most constant manifestation of the disease was leukocyturia (from 4 million to 16 million in the diurnal urine); in half of the patients protein was discharged with the urine (from 40 to 165 mg/day); and erythrocyturia was observed in 3 children (to 4 million). Active leukocytes were released only in 8 patients; bacteriuria (over 100,000 microbe bodies in 1 ml of urine)--in 14.

In study of the functional state of the kidneys in 65 children there was disorder in the urination rhythm, reduction in excretion of ammonia with the urine, titratable acidity, and a shift in the active reaction of the urine to the alkali side. In 48 patients during radio-isotope renography moderate disorders were found in the secretory and excretory phases.

Seventy-eight patients received CMW therapy: 63 of them had primary, 15 had obstructive pyelonephritis. There were 30 children in the control group who were only treated with antibacterial preparations (nitrofurans, biseptol, nevigramon) for 2-week courses.

The "Luch-2" apparatus was used for CMW exposure. The area of projection of the kidneys ( $D_{10}-L_4$ ) was exposed with the patient lying down by using a cylindrical illuminator 11 cm in diameter according to the contact method; the output power for children in age from 5 to 7 was 4 w, from 7 to 10--6 w, over 10--8 w. The procedures lasted 8-10 min and were conducted daily; the treatment course consisted of 6-8-10 procedures (depending on the child's age).

All the children tolerated the procedures well; complications and side effects were not noted during the treatment and after it.

Study of the results of a single procedure indicated that diuresis increased in the children (an average by 0.72 ml/min, and in certain children--by 1.23-1.48 ml/min). The number of excreted leukocytes and erythrocytes, as well as the indices for the function of acido-ammoniogenesis after the procedure did not significantly change, but a tendency towards a certain improvement in them was observed (table 1).

As a result of the course of treatment with CMW for patients with primary pyelonephritis in 59 of the 63 there was a significant reduction in the activity of the microbial-inflammatory process in the kidneys (leukocyturia was reduced, bacteriuria disappeared); excretion of erythrocytes was within the limits of normal oscillations.

Favorable shifts were noted also on the part of the kidney function: increase in minute diuresis (from  $0.88 \pm 0.06$  to  $1.56 \pm 0.05$  ml/min), normalization of urination rhythm (nocturia ceased in 16 of the 22 children), and an improvement in acido-ammoniogenesis (with initial low amounts). This is apparently

Table 1. Excretion of Leukocytes and Erythrocytes, Titratable Acidity, Ammonia, and Urine pH before and after Single CMW Procedure ( $M \pm m$ )

(1) Показатель	(2) До процедуры	(3) После процедуры
Лейкоциты (по Амбурже) (4) P (5)	5898 $\pm$ 520	5155 $\pm$ 873
Эритроциты (по Амбурже) (6) P (5)	385 $\pm$ 86 >0,02	498 $\pm$ 72 >0,02
Титруемая кислотность к стандартной поверхности тела, мэкв/24 ч (норма 55 $\pm$ 2,5 мэкв/24 ч) (7) P (5)	49 $\pm$ 10,5 >0,02	58 $\pm$ 10,0
Аммиак к стандартной поверхности тела, мг/24 ч (норма 600-1000 мг/24 ч) (8) P (5)	643 $\pm$ 79 >0,02	695 $\pm$ 173
pH мочи (9) P (5)	5,4 $\pm$ 0,34 >0,02	6,0 $\pm$ 0,4

Key:

- |   |  |
|---|--|
| 1. Index                                | 7. Titratable acidity for standard body surface, mekv/24 h (norm 55 $\pm$ 2.5 mekv/24 h) |
| 2. Before procedure                     | 8. Ammonia for standard body surface, mg/24 h (norm 600-1000 mg/24 h)                    |
| 3. After procedure                      | 9. Urine pH  |
| 4. Leukocytes (according to Amburzha)   |  |
| 5. D                                    |  |
| 6. Erythrocytes (according to Amburzha) |  |

related to an improvement in the local circulation in the kidneys, as well as in the metabolic processes in the cell, and to an intensification in oxygenation of the blood and tissues (table 2).

Analysis of the renograms of 35 of the 46 examined patients revealed normalization or improvement in the secretory and excretory phases (see figure). These positive shifts on the renograms were maintained also during the next 3-4 months after the end of treatment.

No clear positive effect of CMW treatment was obtained in 12 patients--4 with primary and eight with obstructive pyelonephritis. Here unfavorable dynamics was also noted in the functional indices (exacerbation of renograms, reduction in excretion of ammonia and titratable acidity). These were children with hypotonia of the urine excreting system and considerable disorders in urodynamics.

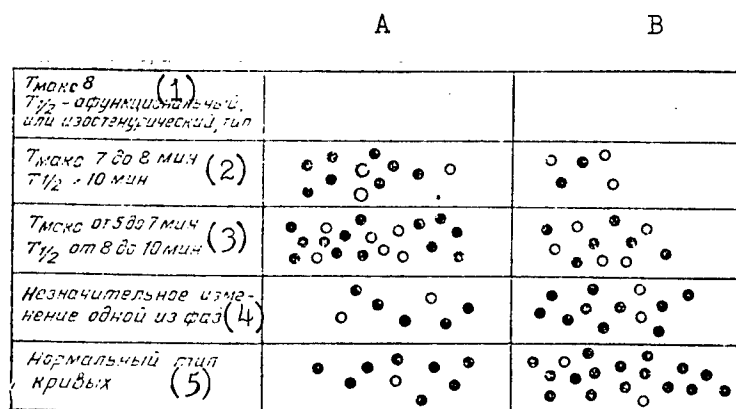
In the control group more pronounced positive dynamics was noted in the activity of the microbial-inflammatory process in the kidneys, however the functional state of the kidneys did not improve, and in 12 patients the acid-ammoniogenetic function significantly decreased, and the renographic indices deteriorated, which apparently can be linked to the reduction in enzymatic-exchange processes in the distal and proximal canaliculi (see table 2 and the figure).

Table 2. Comparative Dynamics for Indices of Activity of Pyelonephritis and Functional State of Kidneys in Children Exposed to CMW Treatment and Chemotherapy (M±m)

Показатель (1)	(2) CMW-терапия (53 детей)		(3) химиотерапия (30 детей)	
	(4) до лечения	после лечения (5)	(4) до лечения	после лечения (5)
Лейкоциты (по Амбурже) (6) P(7)	5829±744	2521±785 <0,02	7514±1340	831±111,4 <0,02
Эритроциты (по Амбурже) (8) P(7)	958±211	740±152 <0,02	1033±434	480±103,9 <0,02
Титруемая кислотность к стандартной поверхности тела, мэкв/24 ч (9) P(7)	42,4±2,58	73,3±4,44 <0,01	61±7,3	43±3,3 <0,02
Аммиак к стандартной поверхности тела, мг/24 ч (10) P(7)	522±38,2	805±45,4 <0,01	590,9±98,6	551±57 >0,02
pH мочи (11) P(7)	5,3±0,24	5,7±0,2 <0,02	5,9±0,27	5,9±0,14 >0,02

Key:

1. Index
2. CMW-therapy (53 children)
3. Chemotherapy (30 children)
4. Before treatment
5. After treatment
6. Leukocytes (according to Amburzha)
7. D
8. Erythrocytes (according to Amburzha)
9. Titratable acidity for standard body surface, mekv/24 h
10. Ammonia for standard body surface, mg/24 h
11. Urine pH



Dynamics of Renograms for CMW Treatment  
A--before, B--after treatment. Dark circles--primary, light--obstructive pyelonephritis.

[Key continued on following page]

Key:

1.  $T_{\max}$  8,  $T_{\frac{1}{2}}$ --afunctional or isosthenuric type
2.  $T_{\max}$  7 to 8 min,  $T_{\frac{1}{2}}$ --10 min
3.  $T_{\max}$  from 5 to 7 min,  $T_{\frac{1}{2}}$  from 8 to 10 min
4. Insignificant change of one of phases
5. Normal type of curves

Thus the results of the conducted studies indicated that the use of CMW for children with primary pyelonephritis promotes not only weakening of the microbial-inflammatory process in the kidneys, but also the restoration of the functional state of the organism which is not noted when only medicinal therapy is used.

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EMPLOYMENT OF POLYETHYLENE AMPOULES AS COVERS FOR MUD VAGINAL TAMPONS\*

Moscow VOPROSY KURORTOLOGII FIZIOTERAPII I LECHEBNOY FIZICHESKOY KULTURY in Russian No 2, 1978 pp 83-85

[Article by N. I. Trofimova, Karagandinskiy Medical Institute]

[Text] Vaginal mud treatment has a history more than a half-century old. It was first used in 1896 by Drs. Shabak in Old Russia and Bastaki in Romania, and it came into practice in 1923. Currently such treatment is widely used for gynecological diseases.

The methods of preparing mud tampons and the techniques for inserting mud into the vagina are continuously being improved. A number of authors (M. S. Belen'kaya, 1927; V. N. Savitskiy, 1931; A. M. Mazhbits, 1957; et al.) have recommended inserting mud into covers, which has a number of important deficiencies: the tampon does not come in close contact with the vaginal walls, and does not stretch them, therefore the action of the mud is not sufficiently effective. In addition, the amount of mud inserted is not great, conducting the procedure requires a lot of time, and the gauze traumatizes the mucous membrane of the vagina.

G. K. Zhivatov (1940) proposed the technique of mud colluminization in which the gauze tampon impregnated with mud with the help of vaginal speculum and forceps is inserted into the vagina filling its vault. This technique also did not become widespread since the amount of mud inserted was considerably smaller than in the aforementioned method of its insertion, and when the tampon was inserted the mud congealed.

Yu. E. Gitel'son, V. G. Dik, V. A. Polubinskiy et al. recommended that the mud, preheated to the necessary temperature be inserted directly into the vagina through a vaginal speculum. This requires considerably more mud (about 200 g), the mucous membrane is not traumatized, but the vaginal vault here is not completely filled with mud.

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\* Innovation No 18 of 14 November 1974.

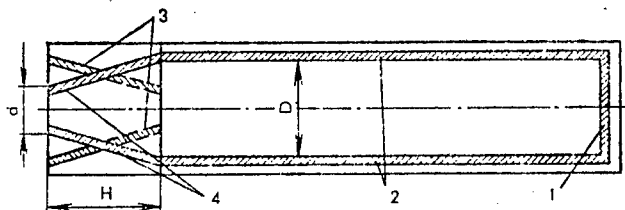


Figure 1. Schematic Diagram of Polyethylene Ampoule. Explanation in text.

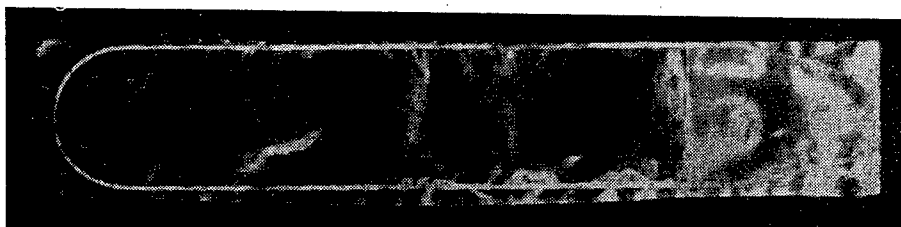


Figure 2. Overall View of Polyethylene Ampoule

N. F. Besspalova-Letova (1929) proposed inserting mud into the vagina with the help of a piece of bicycle inner tube. The advantages of this technique are as follows: the mud in the tube is rapidly and uniformly heated, its amount guarantees the stretching of the vaginal walls and filling of its vaults, with the endurance of the mud little heat is lost and the hygienic requirements are observed. This technique of mud treatment is convenient, but it is also not without deficiencies: the Moor clamps which pinch the ends of the tube with constant contact with mud rapidly corrode and break which does not make it possible to preserve the tampons; after the tubes are used it is necessary to sterilize them for the next operation which requires excess time, and in addition, sterilization of the tubes rapidly destroys the rubber.

In recent years for insertion of mud into the vagina it has been recommended that polyethylene and metallic syringes with removable tips be used (L. A. Chelbiy, 1972; S. N. Osipyan and T. N. Osipyan, 1976).

Since 1969 we have been using polyethylene ampoules as covers for insertion of mud tampons; the design of the ampoules makes it possible to have proportioned packing and sealing of the mud. These ampoules are convenient for transport and simple to use. The ampoule with mud weighs 400-450 g. Figure 1 depicts a schematic diagram of the ampoule made of polyethylene tape (30x6 cm) folded in half. There is a thermal seam along the line of its bending (1), and along its edges--two thermal seams (2). The free ends of the tape are folded inside, two thermal seams have been made along one of

the folded ends (3), and along the folded two ends--also two general thermal seams (4). To fill the ampoule the nozzle of the injection instrument is put into the opening made by seams 4. During the filling of the ampoule one of the folded ends, sutured by seams 3 begins to squeeze against its wall with a force proportional to the pressure of the mud in the ampoule acting as a shut-off valve. Figure 2 shows such an ampoule. The filled ampoule can be stored for a long time and transported any distance. Before use the tampon is heated in an aqueous bath, then the end of the valve is cut and the ampoule contents are forced out directly into the vagina. The polyethylene cover is discarded.

As follows from the aforementioned, to fill the ampoule special attachments are necessary. We use a pump with manual and electric drive. The transfer pump of grease RPN-300 which is also used in industry is a tank with installed manual pump. It is easily loaded with mud through an oval opening; the diameter of the changeable nozzle of the output valve corresponds to the diameter of the ampoule opening. The capacity of the tank is 15 kg of mud, and output is 40-50 ampoules per hour. The low weight of the pump (3.6 kg) and manual drive make it possible to use it under any conditions and to prepare tampons in an unlimited quantity directly at the site of the mud location.

In the hospitals where an electric solids-handling pump 2K-6 has been installed for supplying mud from the mud deposits, we also use a special conical nozzle with an opening corresponding to the diameter of the ampoule opening which is screwed onto the output hose. The ampoules are filled by an electrical pump 2-2 $\frac{1}{2}$  times faster than by manual pump. One can also use machines for making sausages, by employing here special nozzles as in the aforementioned pumps.

Thus, the polyethylene ampoules used as covers for mud vaginal tampons have all the positive qualities inherent to the rubber tubes, and at the same time have a number of advantages: 1) their mass production by plant (Zagorsk) has been set up which guarantees the possibility of acquiring an unlimited number; 2) due to the low cost of the ampoules (1000 cost 22 R) there is no need to re-use them; 3) the tampons can be prepared directly at the site of the mud location and transported to the treatment institutions; 4) the design of the ampoules permits storage in them of the mud for a long time without changing its properties; 5) special clamps are not required which during work with mud rapidly corrode and break down; 6) to fill the ampoules one can use both manual and electrical pumps; 7) the therapeutic mud prepared in the polyethylene ampoules can be used for vaginal and rectal mud treatment.

Thus, as our observations showed, mud tampons made in polyethylene ampoules can be used both at health resorts and outside health resort conditions.

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